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DEPARTMENT OF TRANSPORTATION

National Highway Traffic Safety Administration

49 CFR Parts 523, 531, 533, 535, 536, and 537

[NHTSA–2023–0022]

RIN 2127–AM55

Corporate Average Fuel Economy Standards for Passenger Cars and Light Trucks for Model Years 2027 and Beyond and Fuel Efficiency Standards for Heavy-Duty Pickup Trucks and Vans for Model Years 2030 and Beyond

AGENCY: National Highway Traffic Safety Administration (NHTSA).

ACTION: Final rule.

SUMMARY: NHTSA, on behalf of the Department of Transportation (DOT), is finalizing Corporate Average Fuel Economy (CAFE) standards for passenger cars and light trucks that increase at a rate of 2 percent per year for passenger cars in model years (MYs) 2027–31, 0 percent per year for light trucks in model years 2027–28, and 2 percent per year for light trucks in model years 2029–31. NHTSA is also finalizing fuel efficiency standards for heavy-duty pickup trucks and vans (HDPUVs) for model years 2030–32 that increase at a rate of 10 percent per year and model years 2033–35 that increase at a rate of 8 percent per year.

DATES: This rule is effective August 23, 2024.

ADDRESSES: For access to the dockets or to read background documents or comments received, please visit *https://www.regulations.gov*, and/or Docket Management Facility, M–30, U.S. Department of Transportation, West Building, Ground Floor, Rm. W12–140, 1200 New Jersey Avenue SE, Washington, DC 20590. The Docket Management Facility is open between 9 a.m. and 4 p.m. Eastern time, Monday through Friday, except Federal holidays.

FOR FURTHER INFORMATION CONTACT: For technical and policy issues, Joseph Bayer, CAFE Program Division Chief, Office of Rulemaking, National Highway Traffic Safety Administration, 1200 New Jersey Avenue SE, Washington, DC 20590; email: *joseph.bayer@dot.gov.* For legal issues, Rebecca Schade, NHTSA Office of Chief Counsel, National Highway Traffic Safety Administration, 1200 New Jersey Avenue SE, Washington, DC 20590; email: *rebecca.schade@dot.gov.*

SUPPLEMENTARY INFORMATION:

Table of Acronyms and Abbreviations

Abbreviation	Term
AAA	American Automobile Association.
AALA	American Automotive Labeling Act.
AAPC	The American Automotive Policy Council.
ABT	Average, Banking, and Trading.
AC	Air conditioning.
ACC	Advanced Clean Cars.
ACEEE	American Council for an Energy Efficient Economy.
ACF	Advanced Clean Fleets.
ACME	Adaptive Cylinder Management Engine.
ACT	Advanced Clean Trucks.
ADEAC	advanced cylinder deactivation.
ADEACD	advanced cylinder deactivation on a dual overhead camshaft engine.
ADEACS	advanced cylinder deactivation on a single overhead camshaft engine.
ADSL	Advanced diesel engine.
AEO	Annual Energy Outlook.
AER	All-Electric Range.
AERO	Aerodynamic improvements.
AFV	Alternative fuel vehicle.
AHSS	advanced high strength steel.
AIS	Abbreviated Injury Scale.
AMPC	Advanced Manufacturing Production Tax Credit.
AMTL	Advanced Mobility Technology Laboratory.
ANL	Argonne National Laboratory.
ANSI	American National Standards Institute.
APA	Administrative Procedure Act.
AT	traditional automatic transmissions.
AVE	Alliance for Vehicle Efficiency.
AWD	All-Wheel Drive.
BEA	Bureau of Economic Analysis.
BEV	Battery electric vehicle.
BGEPA	Bald and Golden Eagle Protection Act.
BIL	Bipartisan Infrastructure Law.
BISG	Belt Mounted integrated starter/generator.
BMEP	Brake Mean Effective Pressure.
BNEF	Bloomberg New Energy Finance.
BPT	Benefit-Per-Ton.
BSFC	Brake-Specific Fuel Consumption.
BTW	Brake and Tire Wear.
CAA	Clean Air Act.
CAFE	Corporate Average Fuel Economy.
CARB	California Air Resources Board.
CBD	Center for Biological Diversity.
CBI	Confidential Business Information.
CEA	Center for Environmental Accountability.
CEGR	Cooled Exhaust Gas Recirculation.
CEQ	Council on Environmental Quality.
CFR	Code of Federal Regulations.
CH4	Methane.

Abbreviation	Term
CI	Compression Ignition.
CNG	Compressed Natural Gas.
CO	Carbon Monoxide.
CO2	Carbon Dioxide.
COVID	Coronavirus disease of 2019.
CPM	Cost Per Mile.
CR	Compression Ratio.
CRSS	Crash Report Sampling System.
CUV	Crossover Utility Vehicle.
CVC	Clean Vehicle Credit.
CVT	Continuously Variable Transmissions.
CY	Calendar year.
CZMA	Coastal Zone Management Act.
DCT	Dual Clutch Transmissions.
DD	Direct Drive.
DEAC	Cylinder Deactivation.
DEIS	Draft Environmental Impact Statement.
DFS	Dynamic Fleet Share.
DMC	Direct Manufacturing Cost.
DOE	Department of Energy.
DOHC	Dual Overhead Camshaft.
DOI	Department of the Interior.
DOT	Department of Transportation.
DPM	Diesel Particulate Matter.
DR	Discount Rate.
DSLI	Advanced diesel engine with improvements.
DSLIAD	Advanced diesel engine with improvements and advanced cylinder deactivation.
E.O.	Executive Order.
EFR	Engine Friction Reduction.
EIA	U.S. Energy Information Administration.
EIS	Environmental Impact Statement.
EISA	Energy Independence and Security Act.
EJ	Environmental Justice.
EPA	U.S. Environmental Protection Agency.
EPCA	Energy Policy and Conservation Act.
EPS	Electric Power Steering.
ERF	effective radiative forcing.
ESA	Endangered Species Act.
ESS	Energy Storage System.
ETDS	Electric Traction Drive System.
EV	Electric Vehicle.
FCC	Fuel Consumption Credits.
FCEV	Fuel Cell Electric Vehicle.
FCIV	Fuel Consumption Improvement Value.
FCV	Fuel Cell Vehicle.
FE	Fuel Efficiency.
FEOC	Foreign Entity of Concern.
FHWA	Federal Highway Administration.
FIP	Federal Implementation Plan.
FMVSS	Federal Motor Vehicle Safety Standards.
FMY	Final Model Year.
FRIA	Final Regulatory Impact Analysis.
FTA	Free Trade Agreement.
FTP	Federal Test Procedure.
FWCA	Fish and Wildlife Conservation Act.
FWD	Front-Wheel Drive.
FWS	U.S. Fish and Wildlife Service.
GCWR	Gross Combined Weight Rating.
GDP	Gross Domestic Product.
GES	General Estimates System.
GGE	Gasoline Gallon Equivalents.
GHG	Greenhouse Gas.
GM	General Motors.
gpm	gallons per mile.
GREET	Greenhouse gases, Regulated Emissions, and Energy use in Transportation.
GVWR	Gross Vehicle Weight Rating.
HATCI	Hyundai America Technical Center, Inc.
HCR	High-Compression Ratio.
HD	Heavy-Duty.
HDPUV	Heavy-Duty Pickups and Vans.
HEG	High Efficiency Gearbox.
HEV	Hybrid Electric Vehicle.
HFET	Highway Fuel Economy Test.
HVAC	Heating, Ventilation, and Air Conditioning.

Abbreviation	Term
IACC	improved accessories.
IAV	IAV Automotive Engineering, Inc.
ICCT	The International Council on Clean Transportation.
ICE	Internal Combustion Engine.
IIHS	Insurance Institute for Highway Safety.
IPCC	Intergovernmental Panel on Climate Change.
IQR	Interquartile Range.
IRA	Inflation Reduction Act.
IWG	Interagency Working Group.
LD	Light-Duty.
LDB	Low Drag Brakes.
LDV	Light-Duty Vehicle.
LE	Learning Effects.
LEV	Low-Emission Vehicle.
LFP	Lithium Iron Phosphate.
LIB	Lithium-Ion Batteries.
LIVC	Late Intake Valve Closing.
LT	Light truck.
MAX	maximum values.
MBTA	Migratory Bird Treaty Act.
MD	Medium-Duty.
MDHD	Medium-Duty Heavy-Duty.
MDPCS	Minimum Domestic Passenger Car Standard.
MDPV	Medium-Duty Passenger Vehicle.
MEMA	Motor & Equipment Manufacturer's Association.
MIN	minimum values.
MMTCO2	Million Metric Tons of Carbon Dioxide.
MMY	Mid-Model Year.
MOU	Memorandum of Understanding.
MOVES	Motor Vehicle Emission Simulator (including versions 3 and 4).
MPG	Miles Per Gallon.
mph	Miles Per Hour.
MR	Mass Reduction.
MSRP	Manufacturer Suggested Retail Price.
MY	Model Year.
NAAQS	National Ambient Air Quality Standards.
NACFE	North American Council for Freight Efficiency.
NADA	National Automotive Dealers Association.
NAICS	North American Industry Classification System.
NAS	National Academy of Sciences.
NCA	Nickel Cobalt Aluminum.
NEMS	National Energy Modeling System.
NEPA	National Environmental Policy Act.
NESCCAF	Northeast States Center for a Clean Air Future.
NEVI	National Electric Vehicle Infrastructure.
NHPA	National Historic Preservation Act.
NHTSA	National Highway Traffic Safety Administration.
NMC	Nickel Manganese Cobalt.
NO_X	Nitrogen Oxide.
NPRM	Notice of Proposed Rulemaking.
NRC	National Research Council.
NRDC	Natural Resource Defense Council.
NREL	National Renewable Energy Laboratory.
NTTAA	National Technology Transfer and Advancement Act.
NVH	Noise-Vibration-Harshness.
NVO	Negative Valve Overlap.
NVPP	National Vehicle Population Profile.
OEM	Original Equipment Manufacturer.
OHV	Overhead Valve.
OMB	Office of Management and Budget.
OPEC	Organization of the Petroleum Exporting Countries.
ORNL	Oak Ridge National Laboratories.
PC	Passenger Car.
PEF	Petroleum Equivalency Factor.
PHEV	Plug-in Hybrid Electric Vehicle.
PM	Particulate Matter.
$PM_{2.5}$	fine particulate matter.
PMY	Pre-Model Year.
PPC	Passive Prechamber Combustion.
PRA	Paperwork Reduction Act of 1995.
PRIA	Preliminary Regulatory Impact Analysis.
PS	Power Split.
REMI	Regional Economic Models, Inc.
RFS	Renewable Fuel Standard.

Abbreviation	Term
RIN	Regulation identifier number.
ROD	Record of Decision.
ROLL	Tire rolling resistance.
RPE	Retail Price Equivalent.
RPM	Rotations Per Minute.
RRC	Rolling Resistance Coefficient.
RWD	Rear Wheel Drive.
SAE	Society of Automotive Engineers.
SAFE	Safer Affordable Fuel-Efficient.
SBREFA	Small Business Regulatory Enforcement Fairness Act.
SC	Social Cost.
SCC	Social Cost of Carbon.
SEC	Securities and Exchange Commission.
SGDI	Stoichiometric Gasoline Direct Injection.
SHEV	Strong Hybrid Electric Vehicle.
SI	Spark Ignition.
SIP	State Implementation Plan.
SKIP	refers to skip input in market data input file.
SO_2	Sulfur Dioxide.
SOC	State of Charge.
SOHC	Single Overhead Camshaft.
SOX	Sulfur Oxide.
SPR	Strategic Petroleum Reserve.
SUV	Sport Utility Vehicle.
SwRI	Southwest Research Institute.
TAR	Technical Assessment Report.
TSD	Technical Support Document.
UAW	United Automobile, Aerospace & Agricultural Implement Workers of America.
UF	Utility Factor.
UMRA	Unfunded Mandates Reform Act of 1995.
VCR	Variable Compression Ratio.
VMT	Vehicle Miles Traveled.
VOC	Volatile Organic Compounds.
VSL	Value of a Statistical Life.
VTG	Variable Turbo Geometry.
VTGE	Variable Turbo Geometry (Electric).
VVL	Variable Valve Lift.
VVT	Variable Valve Timing.
WF	Work Factor.
ZEV	Zero Emission Vehicle.

Does this action apply to me?

This final rule affects companies that manufacture or sell new passenger automobiles (passenger cars), non-passenger automobiles (light trucks), and heavy-duty pickup trucks and vans (HDPUVs), as defined under NHTSA's Corporate Average Fuel Economy (CAFE) and medium and heavy duty (MD/HD) fuel efficiency (FE) regulations.[1] Regulated categories and entities include:

Category	NAICS codes[a]	Examples of potentially regulated entities
Industry	335111 336112	Motor Vehicle Manufacturers.
Industry	811111 811112 811198 423110	Commercial Importers of Vehicles and Vehicle Components.
Industry	335312 336312 336399 811198	Alternative Fuel Vehicle Converters.

[a] North American Industry Classification System (NAICS).

This list is not intended to be exhaustive, but rather provides a guide regarding entities likely to be regulated by this action. To determine whether particular activities may be regulated by this action, you should carefully examine the regulations. You may direct questions regarding the applicability of this action to the persons listed in **FOR FURTHER INFORMATION CONTACT**.

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I. Executive Summary

NHTSA, on behalf of the Department of Transportation, is finalizing new corporate average fuel economy (CAFE) standards for passenger cars and light trucks for model years 2027–2031,[2] setting forth augural standards for MY 2032,[3] and finalizing new fuel efficiency standards for heavy-duty pickup trucks and vans[4] (HDPUVs) for model years 2030–2035. This final rule responds to NHTSA's statutory obligation to set CAFE and HDPUV standards at the maximum feasible level that the agency determines vehicle manufacturers can achieve in each MY, in order to improve energy conservation.[5] Improving energy conservation by raising CAFE and HDPUV standard stringency not only helps consumers save money on fuel, but also improves national energy security and reduces harmful emissions.

Based on the information currently before us, NHTSA estimates that relative to the reference baseline[6] this final rule will reduce gasoline consumption by 64 billion gallons relative to reference baseline levels for passenger cars and light trucks and will reduce fuel consumption by approximately 5.6 billion gallons relative to reference baseline levels for HDPUVs through calendar year 2050. If compared to the alternative baseline, which has lower levels of electric vehicle penetration than the reference baseline, fuel savings will be greater at approximately 115 billion gallons.[7] Reducing gasoline consumption has multiple benefits—it improves our nation's energy security, it saves consumers money, and reduces harmful pollutant emissions that lead to adverse human and environmental health outcomes and climate change. NHTSA estimates that relative to the reference baseline, this final rule will reduce carbon dioxide (CO_2) emissions by 659 million metric tons for passenger cars and light trucks, and by 55 million metric tons for HDPUVs through calendar year 2050. Again, these relative reductions are greater if the rule is compared to the alternative baseline, but demonstrating a similar level of absolute carbon dioxide emissions.[8] While consumers could pay more for new vehicles upfront, we estimate that they would save money on fuel costs over the lifetimes of those new vehicles—in the reference baseline analysis lifetime fuel savings exceed modeled regulatory costs by roughly $247, on average, for passenger car and light truck buyers of MY 2031 vehicles, and roughly $491, on average, for HDPUV buyers of MY 2038 vehicles. By comparison, in the No ZEV alternative baseline analysis, lifetime fuel savings exceed modeled regulatory costs by roughly $400, on average, for passenger car and light truck buyers of MY 2031 vehicles. Net benefits for the preferred

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[2] Passenger cars are generally sedans, station wagons, and two-wheel drive crossovers and sport utility vehicles (CUVs and SUVs), while light trucks are generally four-wheel drive sport utility vehicles, pickups, minivans, and passenger/cargo vans. ''Passenger car'' and ''light truck'' are defined more precisely at 49 CFR part 523.

[3] MY 2032, is ''augural,'' as in the 2012 final rule that established CAFE standards for MYs 2017 and beyond. The 2012 final rule citation is 77 FR 62624 (Oct. 15, 2012).

[4] HDPUVs are generally Class 2b/3 work trucks, fleet SUVs, work vans, and cutaway chassis-cab vehicles. ''Heavy-duty pickup trucks and vans'' are more precisely defined at 49 CFR part 523.

[5] *See* 49 U.S.C. 32902.

[6] NHTSA performed an analysis considering an alternative baseline, referenced herein as the ''No ZEV alternative baseline.'' The alternative baseline does not assume manufacturers will consider, or preemptively react to, or voluntarily deploy electric vehicles consistent with any of the California light-duty vehicle Zero Emission Vehicle programs (specifically, ACC I and ACC II) during any of the model years simulated in the analysis, regardless of the fact that ACC I is a legally binding program, and regardless of manufacturer commitments to deploy electric vehicles consistent with ACC II. See TSD Chapter 1.4.2, RIA 3.2, and Section IV.B.2 of this document for further discussion.

[7] Under the CAFE standards finalized in this rule, the absolute amount of fuel use predicted through CY 2050 only differs by 1.4 percent between the reference and alternative baseline analysis.

[8] There is a 1 percent difference between the absolute volume of carbon dioxide (measured in million metric tons, or mmt) produced through CY 2050 in the reference baseline analysis and alternative baseline analysis under the final standards.

alternative for passenger cars and light trucks are estimated to be $35.2 billion at a 3 percent discount rate (DR),[9] and $30.8 billion at a 7 percent DR, and for HDPUVs, net benefits are estimated to be $13.6 billion at a 3 percent DR, and $11.8 billion at a 7 percent DR. Net benefits are higher if the final rules are assessed relative to the alternative baseline, estimated to be $44.9 billion at a 3 percent DR and $39.8 billion at 7 percent DR.[10] (For simplicity, however, all projections presented in this document use the reference baseline unless otherwise stated.)

The record for this action is comprised of the notice of proposed rulemaking (NPRM) and this final rule, a Technical Support Document (TSD), a Final Regulatory Impact Assessment (FRIA), and a Draft and Final EIS, along with extensive analytical documentation, supporting references, and many other resources. Most of these resources are available on NHTSA's website,[11] and other references not available on NHTSA's website can be found in the rulemaking docket, the docket number of which is listed at the beginning of this preamble.

The final rule considers a range of regulatory alternatives for each fleet, consistent with NHTSA's obligations under the Administrative Procedure Act (APA), National Environmental Policy Act (NEPA), and E.O. 12866. Specifically, NHTSA considered five regulatory alternatives for passenger cars and light trucks, as well as the No-Action Alternative. Each alternative is labeled for the type of vehicle and the rate of increase in fuel economy stringency based on changes for each model year, for example, PC1LT3 represents a 1 percent increase in Passenger Car standards and a 3 percent increase in Light Truck standards. We include four regulatory alternatives for HDPUVs, each representing different possible rates of year-over-year increase in the stringency of new fuel economy and fuel efficiency standards, as well as the No-Action Alternative. For example, HDPUV4 represents a 4 percent increase in fuel efficiency standards applicable to HDPUVs. The regulatory alternatives are as follows:[12]

Table I-1: Regulatory Alternatives Under Consideration for MYs 2027-2031 Passenger Car and Light Truck CAFE Standards[13]

Name of Alternative	Passenger Car Stringency Increases, Year-Over-Year	Light Truck Stringency Increases, Year-Over-Year
No-Action Alternative	N/A	N/A
Alternative PC2LT002 (Preferred Alternative)	2%	0% MYs 2027-2028, 2% MYs 2029-2031
Alternative PC1LT3	1%	3%
Alternative PC2LT4	2%	4%
Alternative PC3LT5	3%	5%
Alternative PC6LT8	6%	8%

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[9] The Social Cost of Greenhouse Gases (SC–GHG) assumed a 2 percent discount rate for the net benefit values discussed here.

[10] While the absolute fuel consumption and carbon dioxide emissions are similar when the final standards are applied over both baselines considered, the higher net benefits for the alternative baseline are a result of a larger portion of the reduced fuel use and reduced carbon dioxide being attributed to the CAFE standards rather than to the baseline.

[11] See NHTSA. 2023. Corporate Average Fuel Economy. Available at: *https://www.nhtsa.gov/laws-regulations/corporate-average-fuel-economy.* (Accessed: Feb. 23, 2024).

[12] In a departure from recent CAFE rulemaking trends, we have applied different rates of stringency increase to the passenger car and the light truck fleets in different model years, because the record indicated that different rates of fuel economy were possible. Rather than have both fleets increase their respective standards at the same rate, light truck standards increase at a different rate than passenger car standards in the first two years of the program. This is consistent with NHTSA's obligation to set maximum feasible CAFE standards separately for passenger cars and light trucks (*see* 49 U.S.C. 32902), which gives NHTSA discretion, by law, to set CAFE standards that increase at different rates for cars and trucks. Section VI of this preamble also discusses in greater detail how this approach carries out NHTSA's responsibility under the Energy Policy and Conservation Act (EPCA) to set maximum feasible standards for both passenger cars and light trucks.

[13] Percentages in the table represent the year over year reduction in gal/mile applied to the mpg values on the target curves. The reduction in gal/mile results in an increased mpg.

Table I-2: Regulatory Alternatives Under Consideration for MYs 2030-2035 HDPUV Fuel Efficiency Standards[14]

Name of Alternative	HDPUV Stringency Increases, Year-Over-Year
No-Action Alternative	N/A
Alternative HDPUV4	4%
Alternative HDPUV108 (Preferred Alternative)	10% MYs 2030-2032, 8% MYs 2033-2035
Alternative HDPUV10	10%
Alternative HDPUV14	14%

After assessing these alternatives against the reference baseline and the alternative baseline, and evaluating numerous sensitivity cases, NHTSA is finalizing stringency increases at 2 percent per year for passenger cars for MYs 2027 through 2031, and at 0 percent per year for light trucks for MYs 2027 and 2028, and 2 percent per year for MYs 2029–2031. NHTSA is also setting forth an augural MY 2032 standard that increases at a rate of 2 percent for both passenger cars and light trucks. NHTSA is finalizing stringency increases at 10 percent per year for HDPUVs for MYs 2030–2032, and 8 percent per year for MYs 2033–2035. The regulatory alternatives representing these final stringency increases are called ''PC2LT002'' for passenger cars and light trucks, and ''HDPUV108'' for HDPUVs. These standards are also referred to throughout the rulemaking documents as the ''preferred alternative'' or ''final standards.'' NHTSA concludes that these levels are the maximum feasible for these model years as discussed in more detail in Section VI of this preamble, and in particular given the statutory constraints that prevent NHTSA from considering the fuel economy of battery electric vehicles (BEVs) in determining maximum feasible CAFE standards.[15]

NHTSA notes that due to the statutory constraints that prevent NHTSA from considering the fuel economy of dedicated alternative fueled vehicles, the full (including electric-only operation) fuel economy of dual-fueled alternative fueled vehicles, and the availability of over-compliance credits when determining what standards are maximum feasible, many aspects of our analysis are different from what they would otherwise be without the statutory restrictions—in particular, the technologies chosen to model possible compliance options, the estimated costs, benefits, and achieved levels of fuel economy, as well as the current and projected adoption of alternative fueled vehicles. NHTSA evaluates the results of that constrained analysis by weighing the four enumerated statutory factors to determine which standards are maximum feasible, as discussed in Section VI.A.5.

For passenger cars and light trucks, NHTSA notes that the final year of standards, MY 2032, is ''augural,'' as in the 2012 final rule which established CAFE standards for model years 2017 and beyond. Augural standards mean that they are NHTSA's best estimate of what the agency would propose, based on the information currently before it, if the agency had authority to set CAFE standards for more than five model years in one action. The augural standards do not, and will not, have any effect in themselves and are not binding unless adopted in a subsequent rulemaking. Consistent with past practice, NHTSA is including augural standards for MY 2032 to give its best estimate of what those standards would be to provide as much predictability as possible to manufacturers and to be consistent with the time frame of the Environmental Protection Agency (EPA) standards for greenhouse gas (GHG) emissions from motor vehicles. Due to statutory lead time constraints for HDPUV standards, NHTSA's final rule for HDPUV standards must begin with MY 2030. There is no restriction on the number of model years for which NHTSA may set HDPUV standards, so none of the HDPUV standards are augural.

The CAFE standards remain vehicle-footprint-based, like the current CAFE standards in effect since MY 2011, and the HDPUV standards remain work-factor-based, like the HDPUV standards established in the 2011 ''Phase 1'' rulemaking used in the 2016 ''Phase 2'' rulemaking. The footprint of a vehicle is the area calculated by multiplying the wheelbase times the track width, essentially the rectangular area of a vehicle measured from tire to tire where the tires hit the ground. The work factor (WF) of a vehicle is a unit established to measure payload, towing capability, and whether or not a vehicle has four-wheel drive. This means that the standards are defined by mathematical equations that represent linear functions relating vehicle footprint to fuel economy targets for passenger cars and light trucks,[16] and relating WF to fuel consumption targets for HDPUVs.

The target curves for passenger cars, light trucks, and compression-ignition and spark-ignition HDPUVs are set forth in Sections II and IV; curves for model years prior to the years of the rulemaking time frame are included in the figures for context. NHTSA

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[14] For HDPUVs, the different regulatory alternatives are also defined in terms of percent-increases in stringency from year to year, but in terms of fuel consumption reductions rather than fuel economy increases, so that increasing stringency appears to result in standards going down (representing a direct reduction in fuel consumed) over time rather than up. Also, unlike for the passenger car and light truck standards, because HDPUV standards are measured using a fuel consumption metric, year-over-year percent changes do actually represent gallon/mile differences across the work-factor range.

[15] 49 U.S.C. 32902(h) states that when determining what levels of CAFE standards are maximum feasible, NHTSA ''(1) may not consider the fuel economy of dedicated automobiles [including battery-electric vehicles]; (2) shall consider dual fueled automobiles to be operated only on gasoline or diesel fuel; and (3) may not consider, when prescribing a fuel economy standard, the trading, transferring, or availability of credits under section 32903.''

[16] Generally, passenger cars have more stringent targets than light trucks regardless of footprint, and smaller vehicles will have more stringent targets than larger vehicles, because smaller vehicles are generally more fuel efficient. No individual vehicle or vehicle model need meet its target exactly, but a manufacturer's compliance is determined by how its average fleet fuel economy compares to the average fuel economy of the targets of the vehicles it manufactures.

underscores that the equations and coefficients defining the curves are the CAFE and HDPUV standards, and not the mpg and gallon/100-mile estimates that the agency currently estimates could result from manufacturers complying with the curves. We provide mpg and gallon/100-mile estimates for ease of understanding after we illustrate the footprint curves, but the equations and coefficients are the actual standards. NHTSA is also finalizing new minimum domestic passenger car CAFE standards (MDPCS) for model years 2027–2031 as required by the Energy Policy and Conservation Act of 1975 (EPCA), as amended by the EISA, and applied to vehicles defined as manufactured in the United States. Section 32902(b)(4) of 49 U.S.C. requires NHTSA to project the minimum domestic standard when it promulgates passenger car standards for a MY; these standards are shown in Table I–3 below. NHTSA retains the 1.9 percent offset first used in the 2020 final rule, reflecting prior differences between passenger car footprints originally forecast by the agency and passenger car footprints as they occurred in the real world, such that the minimum domestic passenger car standard is as shown in the table below.

Table I-3: Minimum Domestic Passenger Car Standard with Offset (mpg)

2027	2028	2029	2030	2031	2032 (augural)
55.2	56.3	57.5	58.6	59.8	61.1

Recognizing that many readers think about CAFE standards in terms of the mpg values that the standards are projected to eventually require, NHTSA currently estimates that the standards would require roughly 50.4 mpg in MY 2031, on an average industry fleet-wide basis, for passenger cars and light trucks. NHTSA notes both that real-world fuel economy is generally 20–30 percent lower than the estimated required CAFE level stated above,[17] and also that the actual CAFE standards are the footprint target curves for passenger cars and light trucks. This last note is important, because it means that the ultimate fleet-wide levels will vary depending on the mix of vehicles that industry produces for sale in those model years. NHTSA also calculates and presents ''estimated achieved'' fuel economy levels, which differ somewhat from the estimated required levels for each fleet, for each year.[18] NHTSA estimates that the industry-wide average fuel economy achieved in MY 2031 for passenger cars and light trucks combined could increase from about 52.1 mpg under the No-Action Alternative to 52.5 mpg under the standards.

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[17] CAFE compliance is evaluated per 49 U.S.C. 32904(c) Testing and Calculation Procedures, which states that the EPA Administrator (responsible under EPCA/EISA for measuring vehicle fuel economy) shall use the same procedures used for model year 1975 (weighted 55 percent urban cycle and 45 percent highway cycle) or comparable procedures. Colloquially, this is known as the 2-cycle test. The ''real-world'' or 5-cycle evaluation includes the 2-cycle tests, and three additional tests that are used to adjust the city and highway estimates to account for higher speeds, air conditioning use, and colder temperatures. In addition to calculating vehicle fuel economy, EPA is responsible for providing the fuel economy data that is used on the fuel economy label on all new cars and light trucks, which uses the ''real-world'' values. In 2006, EPA revised the test methods used to determine fuel economy estimates (city and highway) appearing on the fuel economy label of all new cars and light trucks sold in the U.S., effective with 2008 model year vehicles.

[18] NHTSA's analysis reflects that manufacturers nearly universally make the technological improvements prompted by CAFE standards at times that coincide with existing product ''refresh'' and ''redesign'' cycles, rather than applying new technology every year regardless of those cycles. It is significantly more cost-effective to make fuel economy-improving technology updates when a vehicle is being updated. See TSD 2.2.1.7 for additional discussion about manfacturer refresh and redesign cycles.

Table I-4: Estimated Required Average and Estimated Achieved Average of CAFE Levels (mpg) for Passenger Cars and Light Trucks, Reference Baseline, Preferred Alternative PC2LT002[19,20]

Model Year	2022	2027	2028	2029	2030	2031
Passenger Car						
Required	44.1	60.0	61.2	62.5	63.7	65.1
Achieved	47.1	68.6	68.4	68.6	68.6	70.8
Light Truck						
Required	32.1	42.6	42.6	43.5	44.3	45.2
Achieved	32.1	43.7	44.2	44.9	45.3	46.4
Total LD Fleet						
Required	35.8	47.3	47.4	48.4	49.4	50.4
Achieved	36.5	49.9	50.2	50.8	51.1	52.5

To the extent that manufacturers appear to be over-complying in our analysis with required fuel economy levels in the passenger car fleet, NHTSA notes that this is due to the inclusion of several all-electric manufacturers in the reference baseline analysis, which affects the overall average achieved levels. Manufacturers with more traditional fleets do not over-comply at such high levels in our analysis, and our analysis considers the compliance paths for both manufacturer groups. In contrast, while it looks like some manufacturers are falling short of required fuel economy levels in the light truck fleet (and choosing instead to pay civil penalties), NHTSA notes that this appears to be an economic decision by a relatively small number of companies. In response to comments from vehicle manufacturers, in particular manufacturers that commented that they cannot stop manufacturing large fuel inefficient light trucks while also transitioning to manufacturing electric vehicles, NHTSA has reconsidered light truck stringency levels and notes that manufacturers no longer face CAFE civil penalties as modeled in the NPRM. Please see Section VI.D of this preamble for more discussion on these topics and how the agency has considered them in determining maximum feasible standards for this final rule.

For HDPUVs, NHTSA currently projects that the standards would require, on an average industry fleet-wide basis for the HDPUV fleet, roughly 2.851 gallons per 100 miles in MY 2035.[21] HDPUV standards are attribute-based like passenger car and light truck standards, so here, too, ultimate fleet-wide levels will vary depending on what industry produces for sale.

Table I-5: Estimated Required Average and Estimated Achieved Average of Fuel Efficiency Levels (gal/100 miles) for HDPUVs, Preferred Alternative HDPUV108

Fleet	2022	2030	2031	2032	2033	2034	2035
Overall Fleet Required	5.575	4.503	4.074	3.667	3.373	3.102	2.851
Overall Fleet Achieved	5.896	3.421	2.759	2.758	2.603	2.598	2.565

For all fleets, average requirements and average achieved CAFE and HDPUV fuel efficiency levels would ultimately depend on manufacturers' and consumers' responses to standards, technology developments, economic conditions, fuel prices, and other factors.

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[19] There is no actual legal requirement for combined passenger car and light truck fleets, but NHTSA presents information this way in recognition of the fact that many readers will be accustomed to seeing such a value.

[20] The MY 2022 baseline fleet that was used from 2022 NHTSA Pre-Model Year (PMY) data consists of 38% passenger car and 62% light truck.

[21] The HDPUV standards measure compliance in direct fuel consumption and uses gallons consumed per 100 miles of operation as a metric. *See* 49 CFR 535.6.

Our technical analysis for this final rule keeps the same general framework as past CAFE and HDPUV rules, but as applied to the most up-to-date fleet available at the time of the analysis. NHTSA has updated technologies considered in our analysis (removing technologies which are already universal or nearly so and technologies which are exiting the fleet, adding certain advanced engine technologies);[22] updated macroeconomic input assumptions, as with each round of rulemaking analysis; improved user control of various input parameters; updated our approach to modeling manufacturers' expected compliance with states' Zero Emission Vehicle (ZEV) programs and deployment of additional electric vehicles consistent with manufacturer commitments; accounted for changes to DOE's Petroleum Equivalency Factor (PEF),[23] for the reference baseline assumptions; expanded accounting for Federal incentives such as Inflation Reduction Act programs; expanded procedures for estimating new vehicle sales and fleet shares; updated inputs for projecting aggregate light-duty Vehicle Miles Traveled (VMT); and added various output values and options.[24]

NHTSA concludes, as we explain in more detail below, that Alternative PC2LT002 is the maximum feasible alternative that manufacturers can achieve for model years 2027–2031 passenger cars and light trucks, based on a variety of reasons. Energy conservation is still paramount, for the consumer benefits, energy security benefits, and environmental benefits that it provides. Moreover, although the vehicle fleet is undergoing a significant transformation now and in the coming years, for reasons other than the CAFE standards, NHTSA believes that a significant percentage of the on-road (and new) vehicle fleet may remain propelled by internal combustion engines (ICEs) through 2031. NHTSA believes that the final standards will encourage manufacturers producing those ICE vehicles during the standard-setting time frame to achieve significant fuel economy, improve energy security, and reduce harmful pollution by a large amount. At the same time, NHTSA is finalizing standards that our estimates project will continue to save consumers money and fuel over the lifetime of their vehicles while being economically practicable and technologically feasible for manufacturers to achieve.

Although all of the other alternatives, except for the no-action alternative, would conserve more energy and provide greater fuel savings benefits and certain pollutant emissions reductions, NHTSA's statutorily-constrained analysis currently estimates that those alternatives may not be achievable for many manufacturers in the rulemaking time frame.[25] Additionally, the analysis indicates compliance with those more stringent alternatives would impose significant costs (under the constrained analysis) on individual consumers without corresponding fuel savings benefits large enough to, on average, offset those costs. Within that framework, NHTSA's analysis suggests that the more stringent alternatives could push more technology application than would be economically practicable, given anticipated reference baseline activity that will already be consuming manufacturer resources and capital and the constraints of planned manufacturer redesign cycles. In contrast to all other action alternatives, except for the no-action alternative, Alternative PC2LT002 comes at a cost we believe the market can bear without creating consumer acceptance or sales issues, appears to be much more achievable, and will still result in consumer net benefits on average. The alternative also achieves large fuel savings benefits and significant reductions in emissions compared to the no-action alternative. NHTSA concludes Alternative PC2LT002 is the appropriate choice given this record.

For HDPUVs, NHTSA concludes, as explained in more detail below, that Alternative HDPUV108 is the maximum feasible alternative that manufacturers can achieve for model years 2030–2035 HDPUVs. It has been seven years since NHTSA revisited HDPUV standards, and our analysis suggests that there is much opportunity for cost-effective improvements in this segment, broadly speaking. At the same time, we recognize that these vehicles are primarily used to conduct work for a large number of businesses. Although Alternatives HDPUV10 and HDPUV14 would conserve more energy and provide greater fuel savings benefits and CO_2 emissions reductions, they are more costly than HDPUV108, and NHTSA currently estimates that Alternative HDPUV108 is the most cost-effective under a variety of metrics and at either a 3 percent or a 7 percent DR, while still being appropriate and technologically feasible. NHTSA is allowed to consider electrification in determining maximum feasible standards for HDPUVs. As a result, NHTSA concludes that HDPUV108 is the appropriate choice given the record discussed in more detail below, and we believe it balances EPCA's overarching objective of energy conservation while remaining cost-effective and technologically feasible.

For passenger cars and light trucks, NHTSA estimates that this final rule would reduce average fuel outlays over the lifetimes of MY 2031 vehicles by about $639 per vehicle relative to the reference baseline, while increasing the average cost of those vehicles by about $392 over the reference baseline, at a 3 percent discount rate; this represents a difference of $247. With climate benefits discounted at 2 percent and all other benefits and costs discounted at 3 percent, when considering the entire CAFE fleet for model years 1983–2031, NHTSA estimates $24.5 billion in monetized costs and $59.7 billion in monetized benefits attributable to the standards, such that the present value of aggregate net monetized benefits to society would be $35.2 billion.[26] Again, the net benefits are larger if the final rule is assessed relative to the alternative baseline.

For HDPUVs, NHTSA estimates that this final rule could reduce average fuel outlays over the lifetimes of MY 2038 vehicles by about $717 per vehicle, while increasing the average cost of those vehicles by about $226 over the reference baseline, at a 3 percent discount rate; this represents a difference of $491. With climate benefits discounted at 2 percent and all other benefits and costs discounted at 3 percent, when considering the entire on-road HDPUV fleet for calendar years 2022–2050, NHTSA estimates $3.4 billion in monetized costs and $17 billion in monetized benefits attributable to the standards, such that the present value of aggregate net monetized benefits to society would be $13.6 billion.[27]

These assessments do not include important unquantified effects, such as energy security benefits, equity and distributional effects, and certain air quality benefits from the reduction of

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[22] See TSD Chapter 1.1 for a complete list of technologies added or removed from the analysis.

[23] For more information on DOE's final rule, see 89 FR 22041 (Mar. 29, 2024). For more information on how DOE's revised PEF affects NHTSA's results in this final rule, please see Chapter 9 of the FRIA.

[24] See TSD Chapter 1.1 for a detailed discussion of analysis updates.

[25] See Section VI for a complete discussion.

[26] These values are from our ''model year'' analysis, reflecting the entire fleet from MYs 1983–2031, consistent with past practice. Model year and calendar year perspectives are discussed in more detail below in this section.

[27] These values are from our ''calender year'' analysis, reflecting the on-the-road fleet from CYs 2022–2050. Model year and calendar year perspectives are discussed in more detail below in this section.

toxic air pollutants and other emissions, among other things, so the net benefit estimate is a conservative one.[28] In addition, the power sector emissions modeling reflected in this analysis is subject to uncertainty and may be conservative to the extent that other components that influence energy markets, such as recently finalized Federal rules and additional modeled policies like Federal tax credits, are incorporated in those estimates. That said, NHTSA performed additional modeling to test the sensitivity of those estimates and found that in the context of total emissions, any changes from using different power sector forecasts are extremely small. This is discussed in more detail in FRIA Chapter 9.

Table I–6 presents aggregate benefits and costs for new vehicle buyers and for the average individual new vehicle buyer.

Table I-6: Benefits and Costs for the Light Duty (LD) and HDPUV Preferred Alternatives

(2021$, 3 Percent Annual Discount Rate, 2.0 Percent SC-GHG Discount Rate)

	PC2LT002	HDPUV108
Aggregate Buyer Benefits and Costs ($b)		
Costs	16.8	2.4
Benefits	27.0	5.6
Net Benefits	10.3	3.2
Aggregate Societal Benefits and Costs (including buyer, $b)		
Costs	24.5	3.4
Benefits	59.7	17.0
Net Benefits	35.2	13.6
Per-vehicle ($)		
Regulatory Costs	392	226
Lifetime Fuel Savings	639	717

Notes: The components of the costs and benefits totals reported here are presented in Section V.B. Aggregate light-duty measures are computed for the lifetimes of the total light-duty fleet produced through MY 2031. Aggregate HDPUV measures are computed for the on-road HDPUV fleet for calendar years 2022-2050. Per-vehicle costs are those for MY 2031 (LD) and MY 2038 (HDPUV).

NHTSA recognizes that EPA has recently issued a final rule to set new multi-pollutant emissions standards for model years 2027 and later light-duty (LD) and medium-duty vehicles (MDV).[29] EPA describes its final rule as building upon EPA's final standards for Federal GHG emissions standards for passenger cars and light trucks for model years 2023 through 2026 and leverages advances in clean car technology to unlock benefits to Americans ranging from reducing pollution, to improving public health, to saving drivers money through reduced fuel and maintenance costs.[30] EPA's standards phase in over model years 2027 through 2032.[31]

NHTSA coordinated with EPA in developing our final rule to avoid inconsistencies and produce requirements that are consistent with NHTSA's statutory authority. The final rules nevertheless differ in important ways. First, NHTSA's final rule, consistent with its statutory authority and mandate under EPCA/EISA, focuses on improving vehicle fuel economy and not directly on reducing vehicle emissions—though reduced emissions are a follow-on effect of improved fuel economy. Second, the biggest difference between the two final rules is due to EPCA/EISA's statutory prohibition against NHTSA considering the fuel economy of dedicated alternative fueled vehicles, including BEVs, and including the full fuel economy of dual-fueled alternative fueled vehicles in determining the maximum feasible fuel economy level that manufacturers can achieve for passenger cars and light trucks, even though manufacturers may use BEVs and dual-fueled alternative fuel vehicles (AFV) like PHEVs to comply with CAFE standards. EPA is not prohibited from considering BEVs or PHEVs as a compliance option. EPA's final rule is informed by, among other considerations, trends in the automotive industry (including the proliferation of announced investments by automakers in electrifying their fleets), tax incentives under the Inflation Reduction Act (IRA), and other factors in the rulemaking record that are leading to a rapid transition in the automotive industry toward less-pollutant-emitting vehicle technologies. NHTSA, in contrast, may *not* consider BEVs as a compliance option for the passenger car and light truck fleets even though manufacturers may, in fact, use BEVs to comply with CAFE standards. This constraint means that not only are NHTSA's stringency rates of increase

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[28] These cost and benefit estimates are based on many different and uncertain inputs, and NHTSA has conducted several dozen sensitivity analyses varying individual inputs to evaluate the effect of that uncertainty. For example, while NHTSA's reference baseline analysis constrains the application of high compression ratio engines to some vehicles based on performance and other considerations, we also conducted a sensitivity analysis that removed all of those constraints. Results of this and other sensitivity analyses are discussed in Section V of this preamble, in Chapter 9 of the FRIA, and (if large or otherwise significant) in Section VI.D of this preamble.

[29] Multi-Pollutant Emissions Standards for Model Years 2027 and Later Light-Duty and Medium-Duty Vehicles; Final Rule, 89 FR 27842 (Apr. 18, 2024).

[30] *Id.*

[31] *Id.*

different from EPA's but also the shapes of our standards are different based upon the different scopes.

Recognizing these statutory restrictions and their effects on NHTSA's analysis (and that EPA's analysis and decisions are not subject to such constraints) NHTSA sought to optimize the effectiveness of the final CAFE standards consistent with our statutory factors. Our statutorily constrained simulated industry response shows a reasonable path forward to compliance with CAFE standards, but we want to stress that our analysis simply shows feasibility and does not dictate a required path to compliance. Because the standards are performance-based, manufacturers are always free to apply their expertise to find the appropriate technology path that best meets all desired outcomes. Indeed, as explained in greater detail later on in this final rule, it is entirely possible and reasonable that a vehicle manufacturer will use technology options to meet NHTSA's standards that are significantly different from what NHTSA's analysis for this final rule suggests given the statutory constraints under which it operates. NHTSA has ensured that these final standards take account of statutory objectives and constraints while minimizing compliance costs.

As discussed before, NHTSA does not face the same statutory limitations in setting standards for HDPUVs as it does in setting standards for passenger cars and light trucks. This allows NHTSA to consider a broader array of technologies in setting maximum feasible standards for HDPUVs. However, we are still considerate of factors that allow these vehicles to maintain utility and do work for the consumer when we set the standards.

Additionally, NHTSA has considered and accounted for the electric vehicles that manufacturers' have indicated they intend to deploy in our analysis, as part of the analytical reference baseline.[32] Some of this deployment would be consistent with manufacturer compliance with California's Advanced Clean Cars (ACC) I and Advanced Clean Trucks (ACT). We find that manufacturers will comply with ZEV requirements in California and a number of other states in the absence of CAFE standards, and accounting for that expected compliance allows us to present a more realistic picture of the state of fuel economy even in the absence of changes to the CAFE standards. In the proposal, we also included the main provisions of California's Advanced Clean Cars II program (ACC II), which California has adopted but which has not been granted a Clean Air Act preemption waiver by EPA. Because ACC II has not been granted a waiver, we have not included it in our analysis as a legal requirement applying to manufacturers. However, manufacturers have indicated that they intend to deploy additional electric vehicles regardless of whether the waiver is granted, and our analysis reflects these vehicles. Reflecting this expected deployment of electric vehicles for non-CAFE compliance reasons in the analysis improves the accuracy of this reference baseline in reflecting the state of the world without the revised CAFE standards, and thus the information available to decision-makers in their decision as to what standards are maximum feasible, and to the public. However, in order to ensure that the analysis is robust to other possible futures, NHTSA also prepared an alternative baseline—one that reflected none of these electric vehicles (No ZEV Alternative Baseline). The net benefits of the standards are larger under this alternative baseline than they are under the reference baseline, and the technology deployment scenario is reasonable under the alternative baseline, further reinforcing NHTSA's conclusion that the final standards are reasonable, appropriate, and maximum feasible regardless of the deployment of electric vehicles that occurs independent of the standards.

NHTSA notes that while the current estimates of costs and benefits are important considerations and are directed by E.O. 12866, cost-benefit analysis provides only one informative data point in addition to the host of considerations that NHTSA must balance by statute when determining maximum feasible standards. Specifically, for passenger cars and light trucks, NHTSA is required to consider four statutory factors—technological feasibility, economic practicability, the effect of other motor vehicle standards of the Government on fuel economy, and the need of the United States to conserve energy. For HDPUVs, NHTSA is required to consider three statutory factors—whether standards are appropriate, cost-effective, and technologically reasonable—to determine whether the standards it adopts are maximum feasible.[33] As will be discussed further below, NHTSA concludes that Alternatives PC2LT002 and HDPUV108 are maximum feasible on the basis of these respective factors, and the cost-benefit analysis, while informative, is not one of the statutorily-required factors. NHTSA also considered several dozen sensitivity cases varying different inputs and concluded that even when varying inputs resulted in changes to net benefits or (on rare occasions) changed the relative order of regulatory alternatives in terms of their net benefits, those changes were not significant enough to outweigh our conclusion that Alternatives PC2LT002 and HDPUV108 are maximum feasible.

NHTSA further notes that CAFE and HDPUV standards apply only to new vehicles, meaning that the costs attributable to new standards are "front-loaded" because they result primarily from the application of fuel-saving technology to new vehicles. By contrast, the impact of new CAFE and HDPUV standards on fuel consumption and energy savings, air pollution, and GHGs—and the associated benefits to society—occur over an extended time, as drivers buy, use, and eventually scrap these new vehicles. By accounting for many model years and extending well into the future to 2050, our analysis accounts for these differing patterns in impacts, benefits, and costs. Given the front-loaded costs versus longer-term benefits, it is likely that an analysis extending even further into the future would find additional net present benefits.

The bulk of our analysis for passenger cars and light trucks presents a "model year" (MY) perspective rather than a "calendar year" (CY) perspective. The MY perspective considers the lifetime impacts attributable to all passenger cars and light trucks produced prior to MY 2032, accounting for the operation of these vehicles over their entire lives (with some MY 2031 vehicles estimated to be in service as late as 2050). This approach emphasizes the role of the model years for which new standards are being finalized, while accounting for the potential that the standards could induce some changes in the operation of vehicles produced prior to MY 2027 (for passenger cars and light trucks), and that, for example, some individuals might choose to keep older vehicles in operation, rather than purchase new ones.

The calendar year perspective we present includes the annual impacts attributable to all vehicles estimated to be in service in each calendar year for which our analysis includes a representation of the entire registered passenger car, light truck, and HDPUV fleet. For this final rule, this calendar

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[32] Specifically, we include the main provisions of the ACC I and ACT programs, and additional electric vehicles automakers have indicated to NHTSA that they intend to deploy, as discussed further below in Section III.

[33] 49 U.S.C. 32902(k).

year perspective covers each of calendar years 2022–2050, with differential impacts accruing as early as MY 2022.[34] Compared to the MY perspective, the calendar year perspective includes model years of vehicles produced in the longer term, beyond those model years for which standards are being finalized.

The tables below summarize estimates of selected impacts viewed from each of these two perspectives, for each of the regulatory alternatives considered in this final rule, relative to the reference baseline.

Table I-7: Selected Cumulative Effects – Passenger Cars and Light Trucks - MY and CY Perspectives[35]

	PC2LT002 (Final Std.)	PC1LT3	PC2LT4	PC3LT5	PC6LT8
Avoided Gasoline Consumption (billions gallons)					
MYs 1983-2031	-15.0	-20.2	-24.9	-27.2	-31.2
CYs 2022-2050	-63.6	-95.7	-124.8	-153.4	-210.5
Additional Electricity Consumption (TWh)[36]					
MYs 1983-2031	72.8	51.3	50.2	49.4	45.4
CYs 2022-2050	333.3	402.8	514.5	643.7	904.4
Reduced CO2 Emissions (mmt)					
MYs 1983-2031	-155.9	-216.2	-267.0	-291.9	-336.8
CYs 2022-2050	-659.2	-1,003.9	-1,310.0	-1,609.3	-2,204.6

Table I-8: Selected Cumulative Effects – HDPUVs - CY Perspective

	HDPUV4	HDPUV108 (Final Std.)	HDPUV10	HDPUV14
Avoided Gasoline Consumption (billions gallons)				
CYs 2022-2050	-0.5	-5.6	-9.3	-24.2
Additional Electricity Consumption (TWh)				
CYs 2022-2050	4.9	55.5	89.1	246.4
Reduced CO_2 Emissions (mmt)				
CYs 2022-2050	-4.5	-55.0	-91.0	-236.2

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[34] For a presentation of effects by calendar year, please see Chapter 8.2.4.6 of the FRIA.

[35] FRIA Chapter 1, Figure 1–1 provides a graphical comparison of energy sources and their relative change over the standard setting years.

[36] The additional electricity use during regulatory years is attributed to an increase in the number of PHEVs; PHEV fuel economy is only considered in charge-sustaining (*i.e.,* gasoline-only) mode in the compliance analysis, but electricity consumption is computed for the effects analysis.

Table I-9: Estimated Monetized Costs and Benefits – Passenger Cars and Light Trucks - MY and CY Perspectives by Alternative and Social DR, 2% SC-GHG Discount Rate[37,38]

	PC2LT002 (Final Std.)		PC1LT3		PC2LT4		PC3LT5		PC6LT8	
Monetized Benefits ($billion)										
	3% DR	7% DR	3% DR	7% DR	3% DR	7% DR	3% DR	7% DR	3% DR	7% DR
MYs 1983-2031	59.7	47.0	85.8	66.8	107.2	83.1	117.8	91.3	136.6	105.4
CYs 2022-2050	236.9	182.4	362.2	277.4	473.0	362.1	577.9	442.7	787.5	602.5
Monetized Costs ($billion)										
	3% DR	7% DR	3% DR	7% DR	3% DR	7% DR	3% DR	7% DR	3% DR	7% DR
MYs 1983-2031	24.5	16.2	31.8	21.0	47.1	31.0	60.1	39.4	80.8	53.8
CYs 2022-2050	76.8	43.6	115.3	63.4	175.8	96.3	243.4	131.9	352.9	190.4
Monetized Net Benefits ($billion)										
	3% DR	7% DR	3% DR	7% DR	3% DR	7% DR	3% DR	7% DR	3% DR	7% DR
MYs 1983-2031	35.2	30.8	54.0	45.8	60.1	52.1	57.7	51.9	55.8	51.6
CYs 2022-2050	160.1	138.8	247.0	214.1	297.1	265.8	334.4	310.7	434.6	412.1

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[37] Climate benefits are based on changes (reductions) in CO_2, CH_4, and N_2O emissions and are calculated using three different estimates of the SCC, SC–CH_4, and SC–N_2O. Each estimate assumes a different discount rate (1.5 percent, 2 percent, and 2.5 percent). For the presentational purposes of this table and other similar summary tables, we show the benefits associated with the SC–GHG at a 2 percent discount rate. See Section III.G of this preamble for more information.

[38] For this and similar tables in this section, net benefits may differ from benefits minus costs due to rounding.

[39] Climate benefits are based on changes (reductions) in CO_2, CH_4, and N_2O emissions and are calculated using three different estimates of the SCC, SC–CH_4, and SC–N_2O. Each estimate assumes a different discount rate (1.5 percent, 2 percent, and 2.5 percent). For the presentational purposes of this table and other similar summary tables, we show the benefits associated with the SC–GHG at a 2 percent discount rate. See Section III.G of this preamble for more information.

[40] See *https://www.whitehouse.gov/omb/information-regulatory-affairs/reports/* for examples of how this reporting is used by the Federal Government.

Table I-10: Estimated Monetized Costs and Benefits – HDPUVs - CY Perspective by Alternative and Social DR, 2% SC-GHG Discount Rate[39]

	HDPUV4		**HDPUV108 (Final Std.)**		**HDPUV10**		**HDPUV14**	
Monetized Benefits ($billion)								
	3% DR	7% DR	3% DR	7% DR	3% DR	7% DR	3% DR	7% DR
CYs 2022-2050	1.1	1.0	17.0	13.4	27.8	22.0	68.9	56.0
Monetized Costs ($billion)								
	3% DR	7% DR	3% DR	7% DR	3% DR	7% DR	3% DR	7% DR
CYs 2022-2050	0.2	0.1	3.4	1.6	5.6	2.7	13.8	6.7
Monetized Net Benefits ($billion)								
	3% DR	7% DR	3% DR	7% DR	3% DR	7% DR	3% DR	7% DR
CYs 2022-2050	0.9	0.9	13.6	11.8	22.2	19.4	55.1	49.3

Our net benefit estimates are likely to be conservative both because (as discussed above) our analysis only extends to MY 2031 and calendar year 2050 (LD) and calendar year 2050 (HDPUV), and because there are additional important health, environmental, and energy security benefits that could not be fully quantified or monetized. Finally, for purposes of comparing the benefits and costs of CAFE and HDPUV standards to the benefits and costs of other Federal regulations, policies, and programs under the Regulatory Right-to-Know Act,[40] we have computed "annualized" benefits and costs relative to the reference baseline, as follows:

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[41] Climate benefits are based on changes (reductions) in CO_2, CH_4, and N_2O emissions and are calculated using three different estimates of the SCC, SC–CH_4, and SC–N_2O. Each estimate assumes a different discount rate (1.5 percent, 2 percent, and 2.5 percent). For the presentational purposes of this table and other similar summary tables, we show the benefits associated with the SC–GHG at a 2 percent discount rate. See Section III.G of this preamble for more information.

[42] For this and similar tables in this section, net benefits may differ from benefits minus costs due to rounding.

Table I-11: Estimated Annualized Monetized Costs and Benefits – Passenger Cars and Light Trucks - MY and CY Perspectives by Alternative and Social Discount Rate, 2% SC-GHG Discount Rate[41,42]

	PC2LT002 (Final Std.)		PC1LT3		PC2LT4		PC3LT5		PC6LT8	
Monetized Benefits ($billion)										
	3% DR	7% DR	3% DR	7% DR	3% DR	7% DR	3% DR	7% DR	3% DR	7% DR
MYs 1983-2031	2.3	3.4	3.4	4.9	4.2	6.0	4.6	6.6	5.4	7.7
CYs 2022-2050	12.3	14.9	18.9	22.6	24.6	29.5	30.1	36.1	41.0	49.1
Monetized Costs ($billion)										
	3% DR	7% DR	3% DR	7% DR	3% DR	7% DR	3% DR	7% DR	3% DR	7% DR
MYs 1983-2031	1.0	1.2	1.2	1.5	1.8	2.3	2.4	2.9	3.2	3.9
CYs 2022-2050	4.0	3.6	6.0	5.2	9.2	7.8	12.7	10.7	18.4	15.5
Monetized Net Benefits ($billion)										
	3% DR	7% DR	3% DR	7% DR	3% DR	7% DR	3% DR	7% DR	3% DR	7% DR
MYs 1983-2031	1.4	2.2	2.1	3.3	2.4	3.8	2.3	3.8	2.2	3.7
CYs 2022-2050	8.3	11.3	12.9	17.4	15.5	21.7	17.4	25.3	22.6	33.6

Table I-12: Estimated Annualized Monetized Costs and Benefits – HDPUVs by Alternative and Social DR, CY Perspective, 2% SC-GHG Discount Rate[43]

	HDPUV4		HDPUV108 (Final Std.)		HDPUV10		HDPUV14	
Monetized Benefits ($billion)								
	3% DR	7% DR	3% DR	7% DR	3% DR	7% DR	3% DR	7% DR
CYs 2022-2050	0.06	0.08	0.89	1.09	1.45	1.79	3.59	4.56
Monetized Costs ($billion)								
	3% DR	7% DR	3% DR	7% DR	3% DR	7% DR	3% DR	7% DR
CYs 2022-2050	0.01	0.01	0.18	0.13	0.29	0.22	0.72	0.55
Monetized Net Benefits ($billion)								
	3% DR	7% DR	3% DR	7% DR	3% DR	7% DR	3% DR	7% DR
CYs 2022-2050	0.05	0.07	0.71	0.96	1.16	1.58	2.87	4.01

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[43] Climate benefits are based on changes (reductions) in CO_2, CH_4, and N_2O emissions and are calculated using three different estimates of the SCC, SC–CH_4, and SC–N_2O. Each estimate assumes a different discount rate (1.5 percent, 2 percent, and 2.5 percent). For the presentational purposes of this table and other similar summary tables, we show the benefits associated with the SC–GHG at a 2 percent discount rate. See Section III.G of this preamble for more information.

It is also worth emphasizing that, although NHTSA is prohibited from considering the availability of certain flexibilities in making our determination about the levels of CAFE standards that would be maximum feasible, manufacturers have a variety of flexibilities available to aid their compliance. Section VII of this preamble summarizes these flexibilities and what NHTSA has finalized for this final rule. NHTSA is finalizing changes to these flexibilities as shown in Table I–13 and Table I–14.

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[43] Climate benefits are based on changes (reductions) in CO_2, CH_4, and N_2O emissions and are calculated using three different estimates of the SCC, SC–CH_4, and SC–N_2O. Each estimate assumes a different discount rate (1.5 percent, 2 percent, and 2.5 percent). For the presentational purposes of this table and other similar summary tables, we show the benefits associated with the SC–GHG at a 2 percent discount rate. See Section III.G of this preamble for more information.

Table I-13: Overview of Changes to CAFE Program

<table>
<tr><th colspan="4">Fleet Performance Requirements</th></tr>
<tr><th>Component</th><th>Applicable Regulation (Statutory Authority)</th><th>General Description</th><th>Finalized Changes in FRM</th></tr>
<tr><td>Fuel Economy Standards</td><td>49 CFR 531.5 and 49 CFR 533.5 (49 U.S.C. 32902)</td><td>Standards are footprint-based fleet average standards for each of a manufacturer's fleets (i.e., domestic passenger vehicle, import passenger vehicle, and light truck) and expressed in miles per gallon (mpg). NHTSA sets average fuel economy standards that are the maximum feasible for each fleet for each model year. In setting these standards, NHTSA considers technological feasibility, economic practicability, the effect of other motor vehicle standards of the Government on fuel economy, and the need of the U.S. to conserve energy. NHTSA is precluded from considering the fuel economy of vehicles that operate only on alternative fuels, the portion of operation of a dual fueled vehicle powered by alternative fuel, and the trading, transferring, or availability of credits.</td><td>Amendments to 49 CFR 531.5(c)(2) and 49 CFR 533.5(a) to set standards for MY 2027-2031.</td></tr>
<tr><td>Minimum Domestic Passenger Car Standards</td><td>49 CFR 531.5 (49 U.S.C. 32902(b)(4))</td><td>Minimum fleet standards for domestically manufactured passenger vehicles.</td><td>Amendments to 49 CFR 531.5(d) to set standards for MY 2027-2031.</td></tr>
<tr><th colspan="4">Determining Average Fleet Performance</th></tr>
<tr><th>Component</th><th>Applicable Regulation (Statute Authority)</th><th>General Description</th><th>Finalized Changes in FRM</th></tr>
<tr><td>AC efficiency FCIV</td><td>49 CFR 531.6(b)(1) and 49 CFR 533.6(c)(1) (49 U.S.C. 32904) citing 40 CFR 86.1868-12</td><td>This adjustment to the results from the 2-cycle testing accounts for fuel consumption improvement from technologies that improve AC efficiency that are not accounted for in the 2-cycle testing. The AC efficiency FCIV program began in MY 2017 for NHTSA.</td><td>Changes to 49 CFR 531.6 and 533.6 to align with EPA's regulations and eliminate AC efficiency FCIVs for BEVs starting in MY 2027.</td></tr>
<tr><td>Off-cycle FCIV</td><td>49 CFR 531.6(b)(2) and (3) and 49 CFR 533.6(c)(3) and (4) (49 U.S.C. 32904) citing 40 CFR 86.1869-12</td><td>This adjustment to the results from the 2-cycle testing accounts for fuel consumption improvement from technologies that are not accounted for or not fully accounted for in the 2-cycle testing. The off-cycle FCIV program began in MY 2017 for NHTSA.</td><td>Changes to 49 CFR 531.6 and 533.6 to align with EPA's regulations and eliminate off-cycle menu FCIVs for BEVs and to eliminate the 5-cycle and alternative approvals starting in MY 2027. PHEVs retain benefits for ICE operation only. Phasing out off-cycle FCIVs for OCs between MY 2027 and 2033. Adding a 60-day response deadline for requests for information regarding off-cycle requests for MY 2025-2026.</td></tr>
</table>

Table I-14: Overview of Changes to Heavy-Duty Pickups and Vans (HDPUV) Fuel Efficiency Program

Fleet Performance Requirements			
Component	*Applicable Regulation (Statutory Authority)*	*General Description*	*Finalized Changes in FRM*
Fuel Efficiency Standards	49 CFR 535.5 (49 U.S.C. 32902(k))	Standards are attribute-based fleet average standards expressed in gallons per 100 miles. The standards are based on the capability of each model to perform work. A model's work-factor is a measure of its towing and payload capacities and whether equipped with a 4-wheel drive configuration. In setting standards for the Heavy-Duty National Program, NHTSA seeks to implement standards designed to achieve the maximum feasible improvement in fuel efficiency, adopting and implementing test procedures, measurement metrics, fuel economy standards, and compliance and enforcement protocols that are appropriate, cost effective, and technologically feasible.	Amendments to 49 CFR 535.5(a) to set standards for MY2030 and beyond for HDPUVs (with increases in the standards between MY 2030 and 2035).
Determining Average Fleet Performance and Certification Flexibilities			
Component	*Applicable Regulation (Statute Authority)*	*General Description*	*Finalized Changes in FRM*
Innovative and off-cycle technology credits	49 CFR 535.7(a)(1)(iv); 49 CFR 535.7(f)(2) citing 49 CFR 86.1819-14(d)(13), 1036.610 and 1037.610	Manufacturer may generate credits for vehicle or engine families or subconfigurations having fuel consumption reductions resulting from technologies not reflected in the GEM simulation tool or in the FTP chassis dynamometer.	Changes to eliminate innovative and off-cycle technology credits for heavy-duty pickup trucks and vans in MY 2030 and beyond.

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The following sections of this preamble discuss the technical foundation for the agency's analysis, the regulatory alternatives considered in this final rule, the estimated effects of the regulatory alternatives, the basis for NHTSA's conclusion that the standards are maximum feasible, and NHTSA's approach to compliance and enforcement. The extensive record supporting NHTSA's conclusion is documented in this preamble, in the TSD, the FRIA, the Final EIS, and the additional materials on NHTSA's website and in the rulemaking docket.

II. Overview of the Final Rule

A. Summary of the NPRM

In the NPRM, NHTSA proposed new fuel economy standards for LDVs for model years 2027–2031 and new fuel efficiency standards for HDPUVs for model years 2030–2035. NHTSA also set forth proposed augural standards for LDVs for model year 2032. NHTSA explained that it was proposing the standards in response to the agency's statutory mandate to improve energy conservation and reduce the nation's energy dependence on foreign sources. NHTSA also explained that the proposal was also consistent with Executive Order (E.O.) 14037, ''Strengthening American Leadership in Clean Cars and Trucks,'' (August 5, 2021),[44] which directed the Secretary of Transportation (by delegation, NHTSA) to consider beginning work on rulemakings under the Energy Independence and Security Act of 2007 (EISA) to establish new fuel economy standards for LDVs beginning with model year 2027 and extending through at least model year 2030, and to establish new fuel efficiency standards for HDPUVs beginning with model year 2028 and extending through at least model year 2030,[45] consistent with applicable law.[46]

NHTSA discussed the fact that EPA issued a proposal to set new multi-pollutant emissions standards for model years 2027 and later for light-duty and medium-duty vehicles. NHTSA explained that we coordinated with EPA in developing our proposal to avoid inconsistencies and produce requirements that are consistent with NHTSA's statutory authority. The proposals nevertheless differed in important ways, described in detail in the NPRM. EPA has since issued a final rule associated with its proposal,[47] and the interaction between EPA's final standards and NHTSA's final standards is discussed in more detail below.

NHTSA also explained that it had considered and accounted for manufacturers' expected compliance with California's Advanced Clean Cars (ACC I) program and Advanced Clean Trucks (ACT) regulations in our analysis, as part of the analytical reference baseline.[48] We stated that manufacturers will comply with current ZEV requirements in California and a number of other states in the absence of CAFE standards, and accounting for that expected compliance allows us to present a more realistic picture of the state of fuel economy even in the absence of changes to the CAFE standards. NHTSA also incorporated deployment of electric vehicles that would be consistent with California's ACC II program, which has not received a preemption waiver from EPA. However, automakers have indicated their intent to deploy electric vehicles consistent with the levels that would be required under ACCII if a waiver were to be granted, and as such its inclusion similarly makes the reference baseline more accurate. Reflecting expected compliance with the current ZEV programs and manufacturer deployment of EVs consistent with levels that would be required under the ACC II program in the analysis helps to improve the accuracy of the reference baseline in reflecting the state of the world without the revised CAFE standards, and thus the information available to policymakers in their decision as to what standards are maximum feasible and to the public in commenting on those standards. NHTSA also described several other improvements and updates it made to the analysis since the 2022 final rule based on NHTSA analysis, new data, and stakeholder meetings for the NPRM.

NHTSA proposed fuel economy standards for model years 2027–2032 (model year 2032 being proposed augural standards) that increased at a rate of 2 percent per year for both passenger cars and 4 percent per year for light trucks, and fuel efficiency standards for model years 2030–2035 that increased at a rate of 10 percent per year for HDPUVs. NHTSA also took comment on a wide range of alternatives, including no-action alternatives for both light duty vehicles and HDPUVs (retaining the 2022 passenger car and light truck standards and the 2016 final rule for HDPUV standards) and updates to the compliance flexibilities. The proposal was accompanied by a Preliminary Regulatory Impact Analysis (PRIA), a Draft Environmental Impact Statement (Draft EIS), Technical Support Document (TSD) and the CAFE Model software source code and documentation, all of which were also subject to comment in their entirety and all of which received significant comments.

NHTSA tentatively concluded that Alternative PC2LT4 was maximum feasible for LDVs for model years 2027–2031 and Alternative HDPUV10 was maximum feasible for HDPUVs for model years 2030–2035. NHTSA explained that average requirements and achieved CAFE levels would ultimately depend on manufacturers' and consumers' responses to standards, technology developments, economic conditions, fuel prices, and other factors. NHTSA estimated that the proposal would reduce gasoline consumption by 88 billion gallons relative to reference baseline levels for LDVs, and by approximately 2.6 billion gallons relative to reference baseline levels for HDPUVs through calendar year 2050. NHTSA also estimated that the proposal would reduce carbon dioxide (CO_2) emissions by 885 million metric tons for LDVs, and by 22 million metric tons for HDPUVs through calendar year 2050.

In terms of economic effects, NHTSA estimated that while consumers would pay more for new vehicles upfront, they would save money on fuel costs over the lifetimes of those new vehicles—lifetime fuel savings exceed modeled regulatory costs by roughly $100, on average, for model year 2032 LDVs, and by roughly $300, on average, for buyers of model year 2038 HDPUVs. NHTSA estimated that net benefits for the preferred alternative for LDVs would be $16.8 billion at a 3 percent discount rate, and $8.4 billion at a 7 percent discount rate, and for the preferred alternative for HDPUVs would be $2.2 billion at a 3 percent discount rate, and $1.4 billion at a 7 percent discount rate.

NHTSA also addressed the question of harmonization with other motor vehicle standards of the Government that affect fuel economy. Even though NHTSA and EPA issued separate rather than joint notices, NHTSA explained that it had worked closely with EPA in developing the respective proposals, and that the agencies had sought to minimize inconsistency between the programs where doing so was consistent with the agencies' respective statutory mandates. NHTSA emphasized that differences between the proposals, especially as regards programmatic flexibilities, were not new in the proposal, and that differences were often a result of the different statutory frameworks. NHTSA reminded readers that since the agencies had begun regulating concurrently in 2010, these differences have meant that manufacturers have had (and will have) to plan their compliance strategies considering both the CAFE standards and the GHG standards and assure that they are in compliance with both. NHTSA was also confident that industry would still be able to build a single fleet of vehicles to meet both the NHTSA and EPA standards. NHTSA sought comment broadly on all aspects of the proposal.

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[44] E.O. 14037 of Aug 5, 2021 (86 FR 43583).

[45] Due to statutory lead time constraints for HDPUV standards, NHTSA's proposal for HDPUV standards must begin with model year 2030.

[46] *See* 49 U.S.C. Chapter 329, generally.

[47] 89 FR 27842 (Apr. 18, 2024).

[48] Specifically, we include the main provisions of the ACC I, ACC II, (as currently submitted to EPA), and ACT programs, as discussed further below in Section III.C.5.a.

B. Public Participation Opportunities and Summary of Comments

The NPRM was published on NHTSA's website on July 28, 2023, and published in the **Federal Register** on August 17, 2023,[49] beginning a 60-day comment period. The agency left the docket open for considering late comments to the extent practicable. A separate **Federal Register** notice, published on August 25, 2023,[50] announced a virtual public hearing taking place on September 28 and 29, 2023. Approximately 155 individuals and organizations signed up to participate in the hearing. The hearing started at 9:30 a.m. EDT on September 28th and ended at approximately 5:00 p.m., completing the entire list of participants within a single day,[51] resulting in a 141-page transcript.[52] The hearing also collected many pages of comments from participants, in addition to the hearing transcript, all of which were submitted to the docket for the rule.

Including the 2,269 comments submitted as part of the public hearings, NHTSA's docket received a total of 63,098 comments, with tens of thousands of comments submitted by individuals and over 100 deeply substantive comments that included many attachments submitted by stakeholder organizations. NHTSA also received five comments on its Draft EIS to the separate EIS docket NHTSA–2022–0075, in addition to 17 comments on the EIS scoping notice that informed NHTSA's preparation of the Draft EIS.

Many commenters supported the proposal. Commenters supporting the proposal emphasized the importance of increased fuel economy for consumers, as well as cited concerns about climate change, which are relevant to the need of the United States to conserve energy. Commenters also expressed the need for harmonization and close coordination between NHTSA, EPA, and DOE for their respective programs. Many citizens, environmental groups, some States and localities, and some vehicle manufacturers stated strong support for NHTSA finalizing the most stringent alternative.

Many manufacturers urged NHTSA to consider the impact of EPA's standards as well as the impact of DOE's Petroleum Equivalency Factor (PEF) rule on fleet compliance (discussed in more detail below). Many manufacturers supported alignment with EPA's and DOE's standards. Manufacturers were also supportive of keeping the footprint-based standards for LD vehicles and work factor-based standards for HDPUVs. Manufacturers and others were also supportive of continuing the HD Phase 2 approach for HDPUVs by having separate standards for compression ignition (CI) and spark ignition (SI) vehicles, as well as continuing to use a zero fuel consumption value for alternative fuel vehicles such as battery electric vehicles.

In other areas, commenters expressed mixed views on the compliance and flexibilities proposed in the notice. Manufacturers were supportive of maintaining the Minimum Domestic Passenger Car Standard (MDPCS) offset relative to the standards. Most manufacturers and suppliers did not support phasing out off-cycle and AC efficiency fuel consumption improvement values (FCIVs), whereas NGOs and electric vehicle manufacturers supported removing all flexibilities. Many fuel and alternative fuel associations opposed the regulation due to lack of consideration for other types of fuels in NHTSA's analysis.

NHTSA also received several comments on subjects adjacent to the rule but beyond the agency's authority to influence. NHTSA has reviewed all comments and accounted for them where legally possible in the modeling and qualitatively, as discussed below and throughout the rest of the preamble and in the TSD.

NHTSA received a range of comments about the interaction between DOE's Petroleum Equivalency Factor (PEF) proposal and NHTSA's CAFE proposal, mainly from vehicle manufacturers. Several stakeholders commented in support of the proposed PEF,[53] while others commented that the PEF should remain at the pre-proposal level, or even increase.[54] The American Automotive Policy Council (AAPC), the policy organization that represents the ''Detroit Three'' or D3—Ford, General Motors, and Stellantis—commented that DOE's proposed PEF reduction inappropriately devalues electrification, and accordingly ''a devalued PEF yields a dramatic deficiency in light-duty trucks, that make up 83% of the D3's product portfolio.'' [55] The AAPC also commented that ''NHTSA's inclusion of the existing PEF for EVs in 2026 creates an artificially high CAFE compliance baseline, and the proposed PEF post-2027 removes the only high-leverage compliance tool available to auto manufacturers.'' [56] Relatedly, as part of their comments generally opposing DOE's proposed PEF level, other automakers provided alternative values for the PEF,[57] or supported a phase-in of the PEF to better allow manufacturers to restructure their product mix.[58] Other stakeholders urged NHTSA to delay the CAFE rule until DOE adopts a revised PEF,[59] or stated that NHTSA should reopen comments on its proposal following final DOE action on the PEF.[60] Finally, some commenters recommended that NHTSA apply a PEF to the HDPUV segment.[61]

Regarding comments that were supportive of or opposing the new PEF, those comments are beyond the scope of this rulemaking. By statute, DOE is required to determine the PEF value and EPA is required to use DOE's value for calculation of a vehicle's CAFE value.[62] NHTSA has no control over the selection of the PEF value or fuel economy calculation procedures; accordingly, the PEF value is just one input among many inputs used in NHTSA's analysis. While NHTSA was in close coordination with DOE during the pendency of the PEF update process, stakeholder comments about the PEF value and whether the value should be phased in were addressed in DOE's final rule.[63]

As NHTSA does not take a position on the PEF value, the agency believes it was appropriate to use the most up-to-date input assumption at each stage of

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[49] 88 FR 56128 (Aug. 17, 2023).

[50] 88 FR 58232 (Aug. 25, 2023).

[51] A recording of the hearing is provided on NHTSA's website. Avilable at: *https://www.nhtsa.gov/events/cafe-standards-public-hearing-september-2023.* (Acccessed: Jan. 29, 2024).

[52] The transcript, as captured by the stenographer or captioning folks to their best of abilities, is available in the docket for this rule.

[53] Toyota, Docket No. NHTSA–2023–0022–61131, at 9–12; Arconic, Docket No. NHTSA–2023–0022–48374, at 2.

[54] HATCI, Docket No. NHTSA–2023–0022–48991–A1, at 2.

[55] AAPC, Docket No. NHTSA–2023–0022–60610, at 3–5.

[56] *Id.*

[57] HATCI, Docket No. NHTSA–2023–0022–48991–A1, at 2.

[58] HATCI, Docket No. NHTSA–2023–0022–48991–A1, at 2; Volkswagen, Docket No. NHTSA–2023–0022–58702, at 7; Porsche, Docket No. NHTSA–2023–0022–59240, at 7; GM, Docket No. NHTSA–2023–0022–60686, at 6. (*e.g.,* ''In the event that the proposed lower PEF is adopted with a 3-year delay (*i.e.,* lower PEF starts in the 2030 model year), GM could support the NHTSA CAFE Preferred Alternative; however, we note that there are likely to be substantial CAFE/GHG alignment issues starting in 2030.'').

[59] NAM, Docket No. NHTSA–2023–0022–59289, at 2.

[60] The Alliance, Docket No. NHTSA–2023–0022–60652, at 5–6.

[61] MECA Clean Mobility, Docket No. NHTSA–2023–0022–63053, at 4–5; The Aluminum Association, Docket No. NHTSA–2023–0022–58486, at 3; Arconic Corporation, Docket No. NHTSA–2023–0022–48374, at 2.

[62] 49 U.S.C. 32904.

[63] 89 FR 22041 (March 29, 2024).

the analysis to provide stakeholders the best information about the effects of different levels of CAFE standards. NHTSA also included sensitivity analyses in the NPRM with DOE's pre-proposal PEF value so that all stakeholders had notice of and the opportunity to comment on a scenario where the PEF did not change.[64] NHTSA accordingly disagrees that the agency needed to reopen comments on the proposal following final DOE action on the PEF.

NHTSA agrees with AAPC that when a manufacturer's portfolio consists predominantly of lower fuel economy light trucks, as in the particular case of the D3, averaging the fuel economy of those vehicles with high fuel economy BEVs would help them comply with fuel economy standards more so than if BEVs had a lower fuel economy due to a lower PEF. However, this concern is somewhat ameliorated by the changes in DOE's final PEF rule, including a gradual reduction of the fuel content factor.[65] Furthermore NHTSA has determined that the final standards are the maximum feasible fuel economy level that manufacturers can achieve even without producing additional electric vehicles. And, NHTSA disagrees that including in the modeling the old PEF in 2026 and prior and the new PEF in 2027 and beyond ''removes the *only* high-leverage compliance tool available to auto manufacturers'' (emphasis added), as there are several compliance tools available to manufacturers, including increasing the fuel economy of their ICE vehicles. As discussed further in Section VI, NHTSA believes that the standards finalized in this rule explicitly contemplate the concerns expressed by and the capability of all manufacturers.

NHTSA will not use a PEF for HDPUV compliance at this time. NHTSA will continue to use the framework that was put in place by the HD Phase 2 rule, and in coordination with EPA's final rule, by using zero upstream energy consumption for compliance calculations (note that NHTSA does consider upstream effects of electricity use in its effects modeling). Any potential future action on developing PEF for HDPUV compliance would most likely occur in a standalone future rulemaking after NHTSA has a more thorough opportunity to consider the costs and benefits of such an approach and all stakeholders can present feedback on the issue.

NHTSA also received a range of comments about BEV infrastructure. Comments covered both the amount and quality of BEV charging infrastructure and the state of electric grid infrastructure. Some stakeholders, including groups representing charging station providers and electricity providers, commented that although additional investments will be required to support future demand for public chargers and the electricity required for BEV charging, their preparation and planning for the BEV transition is already underway.[66] Many stakeholders emphasized the role of a robust public charging network to facilitate the BEV transition,[67] and broadly urged the Administration to work amongst the agencies and with automakers, utilities, and other interested parties to ensure that BEV charging infrastructure buildout, including developing minimum standards for public charging efficiency, and BEV deployment happen hand in hand.[68]

In contrast, some stakeholders emphasized the current lack of public BEV charging infrastructure as a barrier to EV adoption.[69] Stakeholders also highlighted mechanical problems with existing charging stations,[70] which they stated contributes to dissatisfaction with public charging stations among electric vehicle owners.[71] Other stakeholders commented that the country's electricity transmission infrastructure is not currently in a position to support the expected electricity demand from the BEV transition and may not be in the future for several reasons,[72] such as the lack of materials needed to expand and upgrade the grid.[73] To combat those concerns, other stakeholders recommended that administration officials and congressional leaders prioritize policies that would strengthen transmission systems and infrastructure and speed up their growth.[74] Stakeholders also recommended that NHTSA capture some elements of charging and grid infrastructure issues in its analysis,[75] and outside of the analysis and this rulemaking, identify ways to assist in the realization of adequate BEV infrastructure.[76]

NHTSA acknowledges and appreciates all the comments received on charging infrastructure, which include both broad comments on future grid infrastructure needs, as well as increased deployment of reliable and convenient charging stations. NHTSA agrees with commenters in that infrastructure is an important aspect of a successful transition to BEVs in the future. We also agree that infrastructure improvements are necessary and directly related to keeping pace with projected levels of BEV supply and demand as projected by other agencies and independent forecasters.

With that said, NHTSA projects that manufacturers will deploy a wide variety of technologies to meet the final CAFE standards that specifically are *not* BEVs, considering NHTSA's statutory limitations. As discussed further throughout this preamble, NHTSA does not consider adoption of BEVs in the LD fleet beyond what is already in the reference baseline. Results in Chapter 8 of the FRIA show increased technology penetrations of more efficient

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[64] PRIA, Chapter 9.

[65] 89 FR 22041, at 22050 (March 29, 2024) (''After careful consideration of the comments, DOE concludes that removing the fuel content factor will, over the long term, further the statutory goals of conserving all forms of energy while considering the relative scarcity and value to the United States of all fuels used to generate electricity. This is because, as explained in the 2023 NOPR and in more detail below, by significantly overvaluing the fuel savings effects of EVs in a mature EV market with CAFE standards in place, the fuel content factor will disincentivize both increased production of EVs and increased deployment of more efficient ICE vehicles. Hence, the fuel content factor results in higher petroleum use than would otherwise occur.'').

[66] ZETA, Docket No. NHTSA–2023–0022–60508, at 29–70.

[67] Climate Hawks Civic Action, Docket No. NHTSA–2023–0022–61094, at 2059; U.S. Chamber of Commerce, Docket No. NHTSA–2023–0022–61069, at 5–6.

[68] ZETA, Docket No. NHTSA–2023–0022–60508, at 29–70; MEMA, Docket No. NHTSA–2023–0022–59204, at 10; NAM, Docket No. NHTSA–2023–0022–59203–A1, at 1.

[69] U.S. Chamber of Commerce, Docket No. NHTSA–2023–0022–61069, at 5; NATSO et al., Docket No. NHTSA–2023–0022–61070, at 5–7.

[70] ACI, Docket No. NHTSA–2023–0022–50765, at 4; CFDC et al, Docket No. NHTSA–2023–0022–62242, at 16; NADA, NHTSA–2023–0022–58200, at 10.

[71] CFDC et al, Docket No. NHTSA–2023–0022–62242, at 16.

[72] NAM, Docket No. NHTSA–2023–0022–59289, at 3; ACI, Docket No. NHTSA–2023–0022–50765, at 4; Missouri Corn Growers Association, Docket No. NHTSA–2023–0022–58413, at 2; NCB, Docket No. NHTSA–2023–0022–53876, at 1; AFPM, Docket No. NHTSA–2023–0022–61911–A2, at 41; NATSO et al., Docket No. NHTSA–2023–0022–61070, at 8; West Virginia Attorney General's Office, Docket No. NHTSA–2023–0022–63056, at 12–13; MOFB, Docket No. NHTSA–2023–0022–61601, at 2.

[73] AFPM, Docket No. NHTSA–2023–0022–61911–A2, at 41.

[74] NAM, Docket No. NHTSA–2023–0022–59203, at 3.

[75] For example, some stakeholders stated that technologies like direct current fast chargers (DCFCs) should be prioritized in publicly funded projects and infrastructure decisions, and should be considered to varying extents in NHTSA's analysis. *See, e.g.,* MEMA, Docket No. NHTSA–2023–0022–59204, at 6–7; Alliance for Vehicle Efficiency (AVE), Docket No. NHTSA–2023–0022–60213, at 7; AFPM, Docket No. NHTSA–2023–0022–61911, at 47. Stakeholders also recommended, as an example, NHTSA account for the long lead time for critical grid infrastructure upgrades. MEMA, Docket No. NHTSA–2023–0022–59204–A1, at 3.

[76] MEMA, Docket No. NHTSA–2023–0022–59204–A1, at 3–5.

conventional ICEs, increased penetration of advanced transmissions, increased mass reduction technologies, and other types of electrification such as mild and strong hybrids.

In addition, as discussed further below, NHTSA has coordinated with DOE and EPA while developing this final rule, as requested by commenters. Experts at NHTSA's partner agencies have found that the grid and associated charging infrastructure could handle the increase in BEVs related to both EPA's light- and medium-duty vehicle multi-pollutant rule and the HD Phase 3 GHG rule[77]—significantly more BEVs than NHTSA projects in the LD and HDPUV reference baselines examined in this rule. Thus, infrastructure beyond what is planned for buildout in the rulemaking timeframe, accounting not only for electricity generation and distribution, but considering load-balancing management measures, as well, to improve grid operations, would not be required. It should also be noted that expert projections show an order of magnitude increase in available (domestic) public charging ports between the release of the final rule and the rulemaking timeframe,[78] not accounting for the additional availability of numerous residential and depot chargers. Battery energy storage integration with DC fast chargers can further expedite deployment of necessary infrastructure, reducing lead time for distribution upgrades while increasing the likelihood of meeting public charging needs in the next decade.[79] The National Electric Vehicle Infrastructure (NEVI) program is also investing $5 billion in federal funding to deploy a national network of public EV chargers.[80] Additionally, federally funded charging stations are required to adhere to a set of nationally recognized standards, such as a minimum of 97% annual-uptime,[81] which is anticipated to greatly improve charging reliability concerns of today.

For the HDPUV analysis, NHTSA does consider adoption of BEVs in the standard setting years, and we do see an uptake of BEVs; however, the population of the HDPUV fleet is extremely small, consisting of fewer than 1 million vehicles, compared to the LD fleet that consists of over 14 million vehicles. This means that any potential impact of HDPUV BEV adoption on the electric grid would be similarly small. We also want to note that the adoption of these HDPUV BEVs is driven primarily by factors other than NHTSA's standards, including the market demand for increased fuel efficiency and state ZEV programs, as shown in detail in Section V of this preamble and FRIA Chapter 8.3.2. However, as with LD standards examined in this rule, most manufacturers could choose to meet the preferred standards with limited BEVs. There are still opportunities in the advanced engines, advanced transmissions, and strong hybrid technologies that could be used to meet the HDPUV preferred standards starting in model year 2030.

Although NHTSA does not consider BEVs in its analysis of CAFE stringency, and there is minimal BEV adoption driven by the HDPUV FE standards, NHTSA coordinated with both DOE and EPA on many of the challenges raised by commenters to understand how the infrastructure will be developing and improving in the future. Our review of efforts taking place under the NEVI Program and consultation with DOE and EPA leads us to conclude that (1) there will be sufficient EV infrastructure to support the vehicles included in the light-duty reference baseline and in the HDPUV analysis; and (2) it is reasonable to anticipate that the power sector can continue to manage and improve the electricity distribution system to support the increase in BEVs. DOE and EPA conducted analyses that evaluate potential grid impacts of LD and HD fleet that contain significantly more BEVs than NHTSA's light-duty reference baseline and HDPUV fleets. Their analyses conclude that the implementation of EPA's LD and HD rules can be achieved. DOE and EPA found that sufficient electric grid charging and infrastructure[82] can be deployed, numerous federal programs are providing funding to upgraded charging and grid infrastructure, and managed charging and innovative charging solutions can reduce needed grid updates.[83] The analyses conducted for this assessment of the power sector section covered multiple inputs and assumptions across EPA and DOE tools, such as PEV adoption and EVSE access and utilization, to make sure that all aspects of the grid scenarios modeled are analyzed through 2050 between the no action and action alternative in EPA's rule.

NHTSA also received several comments regarding critical materials used to make EV batteries. In support of its comments that the EV supply chain is committed to supporting full electrification, ZETA provided a thorough recitation of policy drivers supporting critical minerals development, projected demand for critical minerals, and ongoing investments and support from its members for critical mineral production, refining, and processing.[84] Similarly, stakeholders commented about different federal and industry programs, incentives, and investments to promote the production and adoption of electric vehicles.[85] Similar to comments on EV infrastructure, many stakeholders commented that federal agencies should work together to ensure a reliable supply chain for critical minerals.[86]

Other stakeholders commented about several critical minerals issues they perceived to be barriers to a largescale transition to EVs.[87] Stakeholders commented generally on a limited or unavailable supply of certain critical minerals,[88] and more specifically the

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[77] National Renewable Energy Laboratory, Lawrence Berkeley National Laboratory, Kevala Inc., and U.S. Department of Energy. 2024. Multi-State Transportation Electrification Impact Study: Preparing the Grid for Light-, Medium-, and Heavy-Duty Electric Vehicles. DOE/EE–2818, U.S. Department of Energy, (Accessed: May 1, 2024); EPA GHG final rule. RIA Chapter 5.3.

[78] Rho Motion. EV Charging Quarterly Outlook—Quarter 1 2024. Proprietary data. Subscription information available at: *https://rhomotion.com/.*

[79] Poudel, S., et al. Innovative Charging Solutions for Deploying the National Charging Network: Technoeconomic Analysis. United States.

[80] U.S Department of Transportation, Federal Highway Administration. March 5, 2024. National Electric Vehicle Infrastructure (NEVI) Program. Available at: *https://www.fhwa.dot.gov/environment/nevi/.* (Accessed: May 9, 2024).

[81] U.S. Department of Transportation, Federal Highway Administration. Feb. 28, 2023. National Electric Vehicle Infrastructure Standards and Requirements. Available at: *https://www.federalregister.gov/documents/2023/02/28/2023-03500/national-electric-vehicle-infrastructure-standards-and-requirements.* (Accessed: May 1, 2024).

[82] *See* discussion at EPA, Regulatory Impact Analysis, Multi-Pollutant Emissions Standards for Model Years 2027 and Later Light-Duty and Medium-Duty Vehicles, Chapter 5.4.5. *Available at https://www.epa.gov/system/files/documents/2024-03/420r24004.pdf* (last accessed May 22, 2024).

[83] *See id.*

[84] ZETA, Docket No. NHTSA–2023–0022–60508, at 29–39.

[85] States and Cities, Docket No. NHTSA–2023–0022–61904, Appendix at 36–39; ICCT, Docket No. NHTSA–2023–0022–54064, at 2, 7.

[86] NAM, Docket No. NHTSA–2023–0022–59203, at 1.

[87] ACI, Docket No. NHTSA–2023–0022–50765, at 4–7; RFAet al, Docket No. NHTSA–2023–0022–57625, at 2; NAM, Docket No. NHTSA–2023–0022–59203, at 3; AHUA, Docket No. NHTSA–2023–0022–58180, at 6–7; CFDC et al, Docket No. NHTSA–2023–0022–62242, at 22–23; West Virginia Attorney General's Office et al., Docket No. NHTSA–2023–0022–63056, at 13–14.; Valero, Docket No. NHTSA–2023–0022–58547; Mario Loyola and Steven G. Bradbury, Docket No. NHTSA–2023–0022–61952, at 10; MCGA, Docket No. NHTSA–2023–0022–60208; The Alliance, Docket No. NHTSA–2023–0022–60652.

[88] Nissan, Docket No. NHTSA–2023–0022–60696, at 7; AVE, Docket No. NHTSA–2023–0022–60213, at 3–4.

lack of mineral extraction and production in the United States, stating that domestic production of critical minerals is insufficient to meet projected demands.[89] Stakeholders also commented on the potential environmental impact of mining critical minerals,[90] particularly as vehicle manufacturers produce EVs with increasing battery pack sizes.[91] Other stakeholders commented that all of these factors (including costs and environmental impact) should be considered in NHTSA's analysis.[92] Finally, several stakeholders commented on how critical minerals' energy security issues interact with NHTSA's balancing factors to set maximum feasible standards and those comments are addressed in Section VI.5; other stakeholders commented on how critical minerals sourcing interacts with NHTSA's assumptions about tax credits and those comments are addressed in Section III.C.

We appreciate the commenters' feedback in this area and believe that the comments are important to note. However, as we have discussed earlier in this section, the CAFE standards final rulemaking analysis does not include adoption of BEVs beyond what is represented in the reference baseline. We do allow adoption of BEVs in the HDPUV fleet, as EPCA/EISA does not limit consideration of HDPUV technologies in the same way as LD technologies; however, as discussed above, BEV adoption is driven primarily by reasons other than NHTSA's fuel efficiency standards and the number of vehicles that adopt BEV technology in our analysis is relatively (compared to the LD fleet) small. That said, NHTSA believes that commenters' concerns are either currently addressed or are being actively addressed by several public and private endeavors.

NHTSA, in coordination with DOE and EPA, reviewed current supply chain and updated analyses on critical materials. In particular, the DOE, through Argonne National Laboratory, conducted an updated assessment of developing and securing mineral supply for the U.S. electric vehicle industry, the Securing Critical Minerals report.[93] The Argonne study focuses on five materials identified in a previous assessment,[94] including lithium, nickel, cobalt, graphite, and manganese.[95] The study collects and examines potential domestic sources of materials, as well as sources outside the U.S. including Free Trade Agreement (FTA) partners, members of the Mineral Security Partnership (MSP), economic allies without FTAs (referred to as ''Non-FTA countries'' in the Argonne study), and Foreign Entity of Concern (FEOC) sources associated with covered nations, to support domestic critical material demand from anticipated electric vehicle penetration. The assessment considers geological resources and current international development activities that contribute to the understanding of mineral supply security as jurisdictions around the world seek to reduce emissions. The study also highlights current activities that are intended to expand a secure supply chain for critical minerals both domestically and among U.S. allies and partner nations; and considers the potential to meet U.S. demand with domestic and other secure sources. The DOE Securing Critical Minerals report concluded that the U.S. is ''well-positioned to meet its lithium demand through domestic production.'' In the near- and medium-term there is sufficient capacity in FTA and MSP countries to meet demand for nickel and cobalt; however, the U.S. will likely need to rely at least partly on non-FTA counties given expected competition for these minerals from other countries' decarbonization goals. In the near-term, meeting U.S. demand with natural graphite supply from domestic FTA and MSP sources is unlikely. In the medium-term, there is potential for new capacity in both FTA and non-FTA countries, and for synthetic graphite production to scale. The U.S. can rely on FTA and MSP partners, as well as other economic and defense partners, to fill supply gaps; countries with which the U.S. has good trade relations are anticipated to have the ability to assist the U.S. in securing the minerals needed to meet EV *and* ESS (energy storage system) deployment targets set by the Biden Administration.[96] NHTSA considers Argonne's assessment to be thorough and up to date. In addition, it should be noted that DOE's assessments consider critical minerals and battery components to support more than ten million EVs by 2035 [97] [98]—significantly more than we project in our reference baseline.

NHTSA also received a wide variety of comments on alternative fuels including ethanol and biofuels. A group of commenters representing ethanol and biofuel producers objected to NHTSA's handling of BEVs in the analysis, in part because of their views on NHTSA's ability to consider those vehicles under 49 U.S.C. 32902(h), raised energy security concerns with reduced demand for and reliance on U.S.-produced alternative fuels as a result of these regulations, and commented that BEVs would increase reliance on foreign supply chains.[99] Other commenters shared similar sentiments regarding alternative fuels. These commenters stated that NHTSA failed to consider other fuels like ethanol and biofuels as a way to improve fuel economy in the analysis as part of a holistic approach to reducing the U.S.'s gasoline consumption, and therefore the proposed rule was arbitrary.[100] Commenters also stated that NHTSA did not consider the Renewable Fuel Standard (RFS) regulation in this rulemaking, and argued that NHTSA's failure to do so was arbitrary.[101] Finally, commenters recommended that NHTSA consider high octane renewable fuels as a way to improve fuel economy for conventional ICEs.[102]

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[89] ACI, Docket No. NHTSA–2023–0022–50765, at 5; API, Docket No. NHTSA–2023–0022–60234, at 4; AFPM, Docket No. NHTSA–2023–0022–61911, at 2–11.

[90] ACE, Docket No. NHTSA–2023–0022–60683, at 2–3.

[91] ACI, Docket No. NHTSA–2023–0022–50765.

[92] ACE, Docket No. NHTSA–2023–0022–60683, at 3; MECA, Docket No. NHTSA–2023–0022–63053, at 8.

[93] Barlock, T. et al. Securing Critical Materials for the U.S. Electric Vehicle Industry: A Landscape Assessment of Domestic and International Supply Chains for Five Key Battery Materials. United States. Available at: *https://doi.org/10.2172/2319240.* (Accessed: May 1, 2024).

[94] Department of Energy, July 2023. Critical Materials Assessment. Available at: *https://www.energy.gov/sites/default/files/2023-07/doe-critical-material-assessment_07312023.pdf.* (Accessed: May 1, 2024).

[95] The 2023 DOE Critical Minerals Assessment classifies manganese as ''non critical'', as reflected in the Securing Critical Minerals report referenced.

[96] Associated with the implementation of the BIL and IRA.

[97] See Figure 14 in Barlock, T.A. et al. February 2024. Securing Critical Materials for the U.S. Electric Vehicle Industry. ANL–24/06. Final Report. Available at: *https://publications.anl.gov/anlpubs/2024/03/187907.pdf.* (Accessed: Apr. 5, 2024).

[98] See in Gohlke, D. et al. March 2024. Quantification of Commercially Planned Battery Component Supply in North America through 2035. ANL–24/14. Final Report. Available at: *https://publications.anl.gov/anlpubs/2024/03/187735.pdf* (Accessed: June 3, 2024).

[99] BSC, Docket No. NHTSA–2023–0022–50824 at 1; MME, Docket No. NHTSA–2023–0022–50861 at 2; WPE, Docket No. NHTSA–2023–0022–52616 at 2; POET, Docket No. NHTSA–2023–0022–61561 at 6; SIRE, Docket No. NHTSA–2023–0022–57940 at 2.

[100] Growth Energy, Docket No. NHTSA–2023–0022–61555 at 1; KCGA, Docket No. NHTSA–2023–0022–59007 at 5; POET, Docket No. NHTSA–2023–0022–61561 at 5; Toyota, Docket No. NHTSA–2023–0022–61131 at 2; Commenwealth Agri Energy LLC, Docket No. NHTSA–2023–0022–61599 at 3; MEMA, Docket No. NHTSA–2023–0022–59204 at 3; AFPM, Docket No. NHTSA–2023–0022–61911 at 25.

[101] Growth Energy, Docket No. NHTSA–2023–0022–61555 at 2.

[102] NCB, Docket No. NHTSA–2023–0022–53876 at 2; CFDC et al., Docket No. NHTSA–2023–0022–

NHTSA believes that fuel producers' comments about NHTSA's purported inability to consider BEVs under 49 U.S.C. 32902(h) are somewhat misguided, considering that EPCA's definition of ''alternative fuel'' in 49 U.S.C. 32901 also includes ethanol, other alcohols, and fuels derived from biological materials, among other fuels.[103] This means that if NHTSA were to adopt the fuel producers' interpretation of 49 U.S.C. 32902(h) to restrict BEV adoption in the reference baseline, NHTSA would have to take an analogous approach to limit the agency's consideration of vehicles fueled by other alternative fuels, for example, ethanol, in the reference baseline. This is because 49 U.S.C. 32902(h) does not just place guardrails on NHTSA's consideration of manufacturers producing BEVs in response to CAFE standards, but all dedicated alternative fueled automobiles, and fuels produced by the commenters here are, as listed above, considered alternative fuels. NHTSA does consider some alternative-fueled vehicle adoption in the reference baseline where that adoption is driven for reasons other than NHTSA's standards (see Section IV), and the commenters do mention the RFS as a driver of the increased use of renewable alternative fuels like ethanol and biofuels. However, the RFS is a regulation that increases the use of renewable fuels to replace petroleum derived fuels in motor gasoline, and to the extent that EPA has approved the use of E15 in all model year 2001 and newer gasoline vehicles produced for the U.S. market, we account for that in our analysis. NHTSA also considers flexible fuel vehicles (FFVs) that exist in the reference baseline fleet in the analysis, however FFVs are also subject to the restrictions in 49 U.S.C. 32902(h)(2).[104] NHTSA applies the same CAFE Model restrictions in the standard-setting analysis to FFVs that apply to PHEVs to ensure that the agency is not improperly considering the alternative-fueled operation of dual-fueled vehicles when setting CAFE standards.[105]

There is also a practical consideration that while blending ethanol or biofuels with gasoline has the potential to reduce U.S. reliance on petroleum, renewable fuels like ethanol and biofuels decrease fuel economy.[106] The fuel economy of FFVs operating on high-ethanol blends are worse than when operating on conventional gasoline, because although ethanol has a higher octane rating than petroleum gasoline, it is less energy dense. For example, a model year 2022 Ford F150 4WD achieves a real world combined 20 mpg rating on conventional gas versus 15 mpg on alternative E85 fuel.[107] FFVs do see a compliance boost in the CAFE program with a 0.15 multiplier,[108] however, again NHTSA's consideration of those vehicles' fuel economy values to set higher fuel economy standards is limited by 49 U.S.C. 32902(h)(2).

Regarding comments about energy security, we discuss this further in preamble Section VI. As mentioned above, commenters suggested that consideration of BEVs also impacts NHTSA's statutory considerations of energy security. However, NHTSA does not consider BEVs in its standard-setting, and notes that this final rule is not a BEV mandate, as claimed by some commenters. Results in preamble Section V and FRIA Chapter 8 show that manufacturers have a wide variety of technology options to meet both LD and HDPUV standards, and the paths to compliance modeled in this analysis represent only a possible path, and not a required path. NHTSA does not mandate any one technology that manufacturers must use, hence why we have evaluated an array of technologies for manufacturers to use for meeting the standards. As with other technologies in the analysis, nothing prevents manufacturers from using FFVs or other dedicated alternative fueled vehicles to comply with CAFE standards.

Finally, NHTSA received a wide variety of comments on compliance aspects of the CAFE program. Although most of them have been summarized and discussed in Section VII of this preamble, we received comments regarding the fuel economy utility factor (UF) compliance calculation for plug-in hybrids. Mitsubishi commented that NHTSA failed to account for EPA's proposal to update the UF calculation for the combined fuel economy for PHEVs, stating that ''[t]he result is that NHTSA overestimated the value of PHEV CAFE compliance and underestimated the costs of achieving compliance.'' [109] On the other hand, ICCT and the Strong PHEV Coalition supported NHTSA using EPA's new proposed UF approach for the rulemaking analysis.[110] MECA supported NHTSA's continued use of SAE J2841 and recommended that, at a minimum, we should not reduce the UF from the current levels.[111]

We appreciate stakeholders providing comments to NHTSA on PHEV fuel economy calculations. While in the CAFE modeling NHTSA uses SAE J2841 to calculate PHEV fuel economy, for CAFE compliance, NHTSA must use EPA's test procedures.[112] This means that EPA will report fuel economy values to NHTSA beginning in model year 2031 consistent with the new PHEV UF finalized in EPA's final rule. NHTSA chose to use SAE J841 as a simplifying assumption in the model for this analysis to reduce analytical complexity and based on a lack of readily available data from manufacturers; however, choosing to use SAE J2841 versus another PHEV UF results in functionally no difference in NHTSA's standard setting analysis because for the purpose of setting fuel economy standards, NHTSA cannot consider the electric portion of PHEV operation, per statute.[113] For more detailed discussion of modeled PHEV fuel economy values, see TSD Chapter 3.3.

Discussion and responses to other comments can be found throughout this preamble in areas applicable to the comment received.

Nearly every aspect of the NPRM analysis and discussion received some level of comment by at least one commenter. Overall, the comments received included both broad assessments and pointed analyses, and the agency appreciates the level of engagement of commenters in the public comment process and the information and opinions provided.

C. Changes to the CAFE Model in Light of Public Comments and New Information

Comments received to the NPRM were considered carefully within the statutory authority provided by the law, because they are critical for

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62242 at 17–20; NATSO et al., Docket No. NHTSA–2023–0022–61070 at 9.

[103] 49 U.S.C. 32901(a)(1).

[104] 49 U.S.C. 32901(a)(9); 49 U.S.C. 32902(h)(2).

[105] CAFE Model Documentation, S5.

[106] **Fueleconomy.gov.** New Flex-fuel Vehicles for model year 2012 to model year 2025. Available at: *https://www.fueleconomy.gov/feg/flextech.shtml.* (Accessed: Apr. 12, 2024).

[107] DOE Alternative Fuels Data Center. Ethanol E85 Vehicles for model year 2022–2024. Available at: *https://afdc.energy.gov/vehicles/search/data.* (Accessed: Apr. 12, 2024).

[108] 40 CFR 600.510–12(c)(2)(v).

[109] Mitsubishi, Docket No. NHTSA–2023–0022–61637 at 4.

[110] ICCT, Docket No. NHTSA–2023–0022–54064 at 25; Strong PHEV Colaition, Docket No. NHTSA–2023–0022–60193 at 6.

[111] MECA, Docket No. NHTSA–2023–0022–63053, at 6.

[112] 40 CFR 600.116–12: Special procedures related to electric vehicles and hybrid electric vehicles.

[113] U.S.C 32902(h)(2).

understanding stakeholders' positions, as well as for gathering additional information that can help to inform the agency about aspects or effects of the proposal that the agency may not have considered at the time of the proposal was issued. The views, data, requests, and suggestions contained in the comments help us to form solutions and make appropriate adjustments to our proposals so that we may be better assured that the final standards we set are reasonable for the rulemaking time frame. For this final rule, the agency made substantive changes resulting directly from the suggestions and recommendations from commenters, as well as new information obtained since the time the proposal was developed, and corrections both highlighted by commenters and discovered internally. These changes reflect DOT's long-standing commitment to ongoing refinement and improvement of its approach to estimating the potential impacts of new CAFE standards. Through further consideration and deliberation, and also in response to many public comments received since then, NHTSA has made a number of changes to the CAFE Model since the 2023 NPRM, including those that are listed below and detailed in Section II and III, as well as in the TSD and FRIA that accompany this final rule.

D. Final Standards—Stringency

NHTSA is establishing new CAFE standards for passenger cars (PCs) and light trucks (LTs) produced for model years 2027–2031, setting forth augural CAFE standards for PCs and LTs for model year 2032, and establishing fuel efficiency standards for HDPUVs for model years 2030–2035. Passenger cars are generally sedans, station wagons, and two-wheel drive crossovers and sport utility vehicles (CUVs and SUVs), while light trucks are generally 4WD sport utility vehicles, pickups, minivans, and passenger/cargo vans.[114] NHTSA is establishing standards (represented by alternative PC2LT002, which is the preferred alternative in our analysis) that increase in stringency at 2 percent per year for PCs produced for model years 2027–2031 (and setting forth augural standards that would increase by another 2 percent for PCs produced in model year 2032), at 0 percent per year for LTs produced in model years 2027–2028 and 2 percent per year for LTs produced in model years 2029–2031 (and setting forth augural standards that would increase by another 2 percent for LTs produced in model year 2032). Passenger car and light truck standards are all attribute-based. NHTSA is setting CAFE standards defined by a mathematical function of vehicle footprint,[115] which has an observable correlation with fuel economy. The final standards, and regulatory alternatives, take the form of fuel economy targets expressed as functions of vehicle footprint, which are separate for PCs and LTs. Section IV below discusses NHTSA's continued reliance on footprint as the relevant attribute for PCs and LTs in this final rule.

The target curves for the final passenger car and light truck standards are as follows; curves for model years 2024–2026 are included in the figures for context. NHTSA underscores that the equations and coefficients defining the curves are, in fact, the CAFE standards, and not the mpg numbers that the agency estimates could result from manufacturers complying with the curves. Because the estimated mpg numbers are an effect of the final standards, they are presented in Section II.E. To give context to what the passenger car footprint curve is showing in Figure II–1, for model year 2024, the target for the smallest footprint passenger cars is 55.4 mpg, and the target for the largest footprint passenger cars is 41.5 mpg. For model year 2031, the smallest footprint passenger cars have a target of 74.1 mpg and the largest passenger cars have a target of 55.4 mpg.

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[114] "Passenger car" and "light truck" are defined at 49 CFR part 523.

[115] Vehicle footprint is roughly measured as the rectangle that is made by the four points where the vehicle's tires touch the ground. Generally, passenger cars have more stringent targets than light trucks regardless of footprint, and smaller vehicles will have more stringent targets than larger vehicles. No individual vehicle or vehicle model need meet its target exactly, but a manufacturer's compliance is determined by how its average fleet fuel economy compares to the average fuel economy of the targets of the vehicles it manufactures.

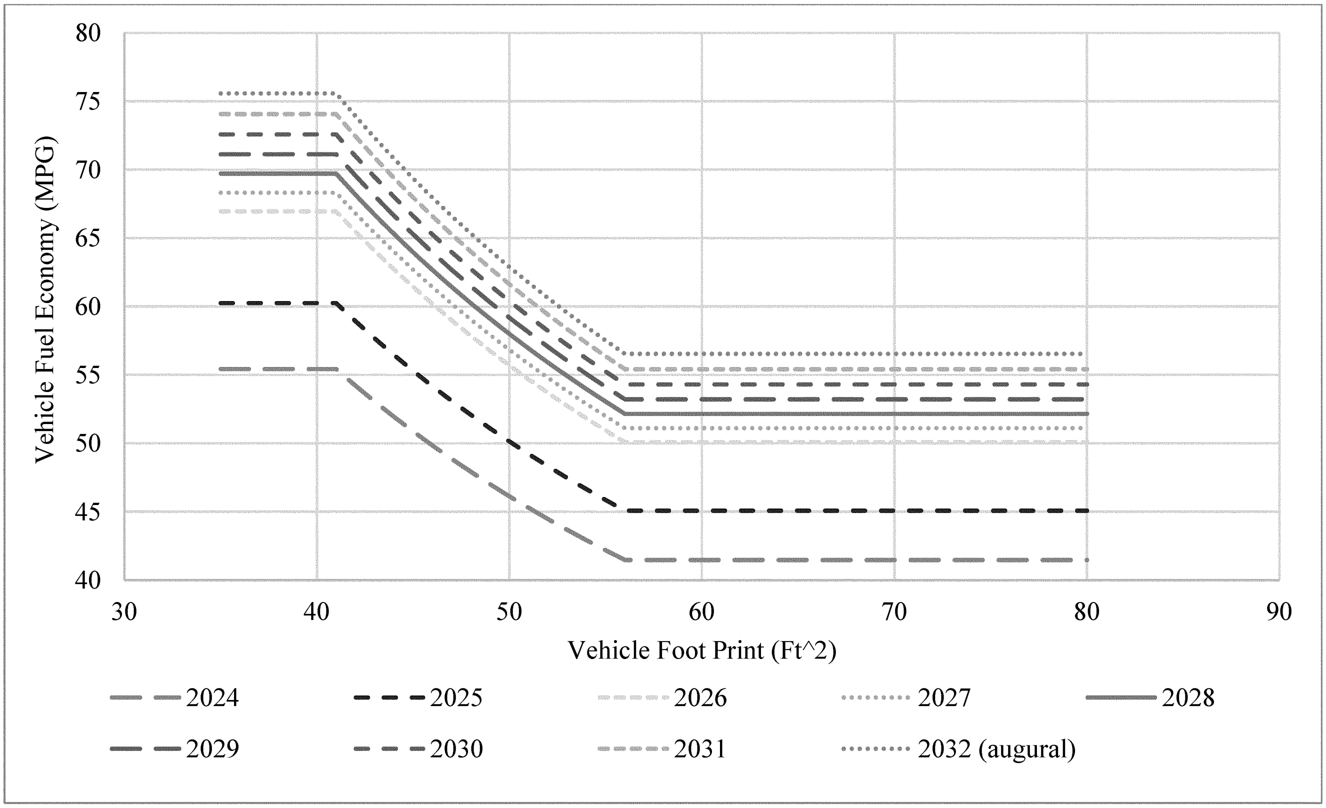

Figure II-1: Final Passenger Car Fuel Economy Standards, Target Curves

To give context to what the light truck footprint curve is showing in Figure II–2, the smallest footprint truck fuel economy target is 44.5 mpg, and the largest truck fuel economy target is 26.7 mpg. And in model year 2031, the smallest truck footprint target is 57.1 mpg, and the largest truck footprint target is 34.3 mpg.

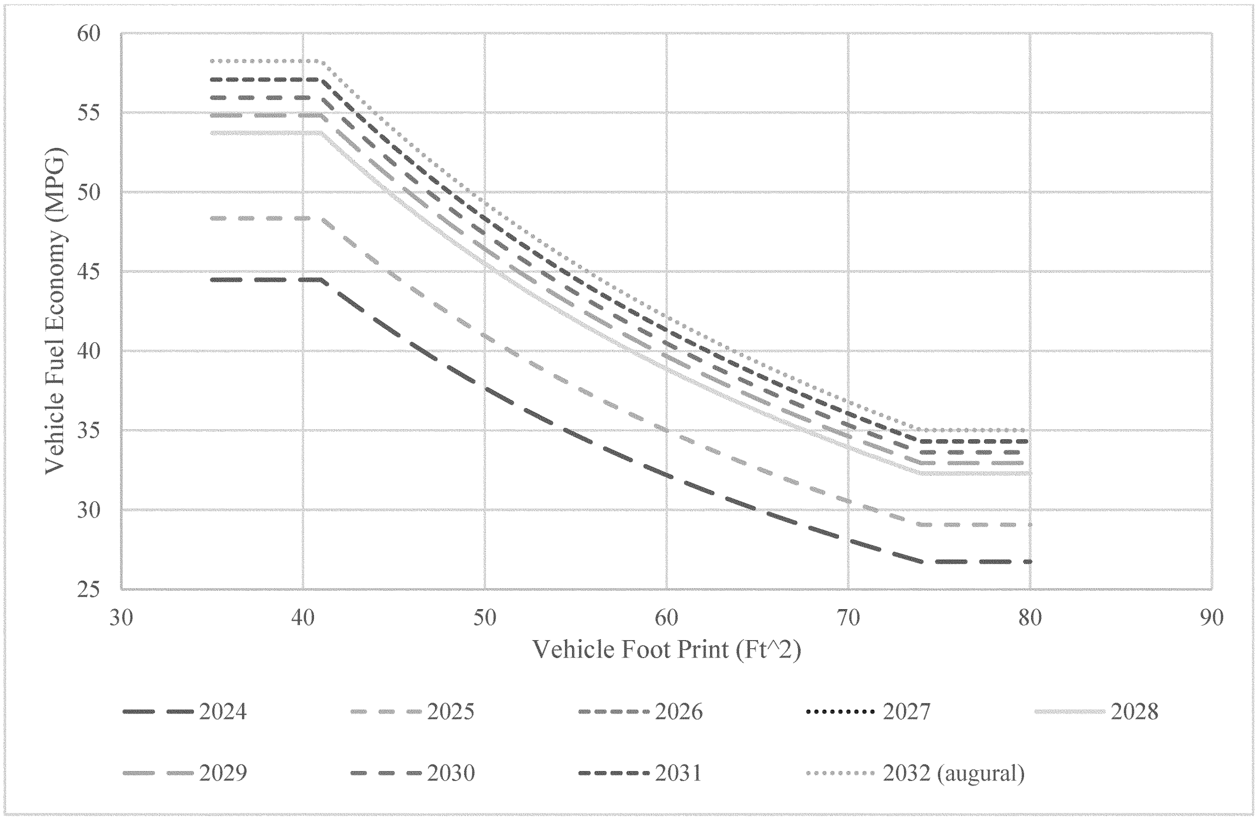

Figure II-2: Final Light Truck Fuel Economy Standards, Target Curves

NHTSA has also amended the minimum domestic passenger car standard (MDPCS) for model years 2027–2031 and set forth an augural MDPCS for model year 2032. Section 32902(b)(4) of 49 U.S.C. requires NHTSA to project the MDPCS when it promulgates passenger car standards for a model year, as a result the MDPCSs are established as specific mpg values. NHTSA retains the 1.9-percent offset to the MDPCS, first used in the 2020 final rule, to account for recent projection errors as part of estimating the total passenger car fleet fuel economy.[116] The final MDPCS for model years 2027–2031 and the augural MDPCS for model year 2032 for the preferred alternative are presented in Table II–1.

Table II-1: Final Minimum Domestic Passenger Car Standard (MPG)

2027	2028	2029	2030	2031	2032 (augural)
55.2	56.3	57.5	58.6	59.8	61.1

Heavy-duty pickup trucks and vans are work vehicles that have GVWR between 8,501 pounds to 14,000 pounds (known as Class 2b through 3 vehicles) manufactured as complete vehicles by a single or final stage manufacturer or manufactured as incomplete vehicles as designated by a manufacturer.[117] The majority of these HDPUVs are ¾-ton and 1-ton pickup trucks, 12- and 15-passenger vans, and large work vans that are sold by vehicle manufacturers as complete vehicles, with no secondary manufacturer making substantial modifications prior to registration and use. The final standards, represented by alternative HDPUV108 in NHTSA's analysis, increases at a rate of 10 percent per year for model years 2030–2032 and 8 percent per year for model years 2033–2035. The final standards, like the proposed standards, are defined by a linear work factor target function with two sets of sub-configurations with one for spark ignition (SI) that represents gasoline, CNG, strong hybrids, and PHEVs and the other for compression ignition (CI) that represents diesels, BEVs and FCEVs. The target linear curves for HDPUV are still in the same units as in Phase 2 final rule in gallons per 100 miles and for context both the

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[116] Section VI.A.2 (titled "Separate Standards for Passenger Cars, Light Trucks, and Heavy-Duty Pickups and Vans, and Minimum Standards for Domestic Passenger Cars") discusses the basis for the offset.

[117] *See* 49 CFR 523.7, 40 CFR 86.1801–12, 40 CFR 86.1819–17, 40 CFR 1037.150.

SI and CI curves are shown for model years 2026–2035.

Table II-2: Final CI Vehicle Standards, Target Coefficients (gal/100 mi)[118]

	2030	2031	2032	2033	2034	2035
e	0.00030762	0.00027686	0.00024917	0.00022924	0.00021090	0.00019403
f	2.370	2.133	1.919	1.766	1.625	1.495

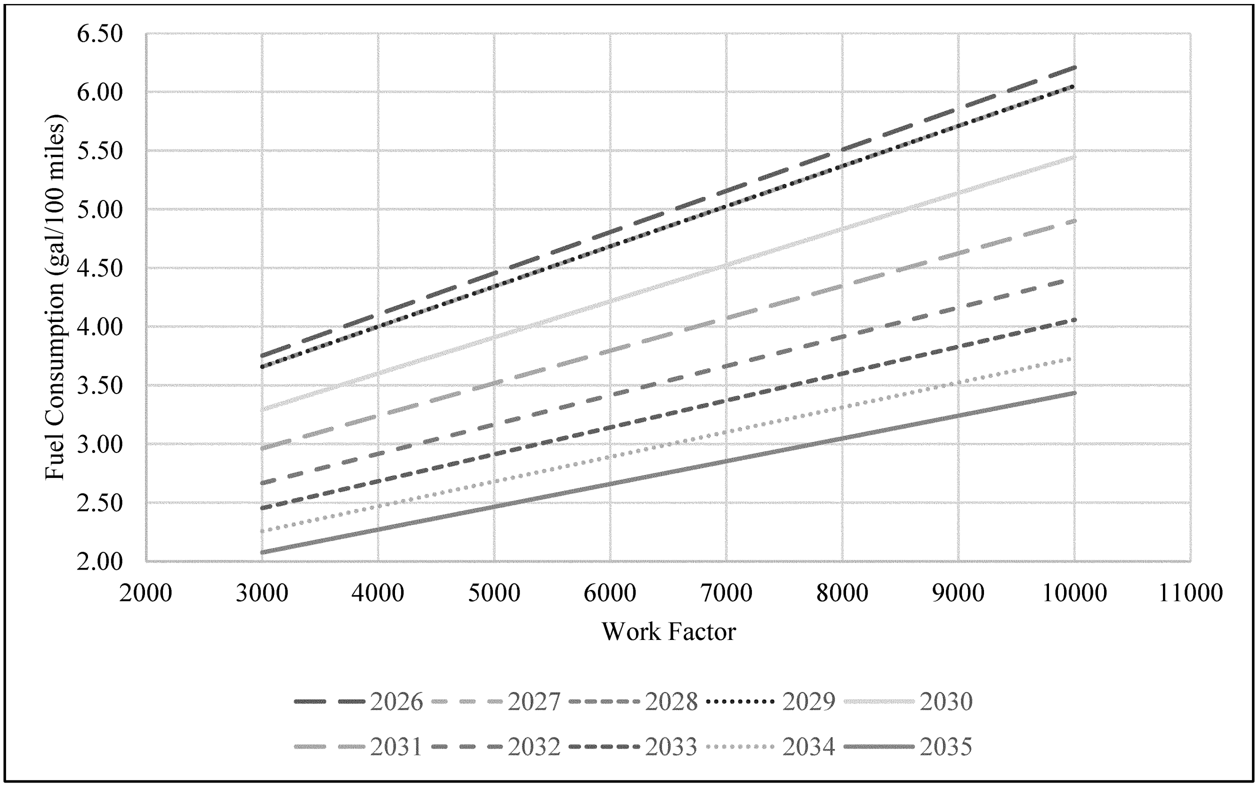

Figure II-3: Final CI Vehicle Standards, Target Curves

Table II-3: Final SI Vehicle Standards, Target Coefficients (gal/100 mi)[119]

	2030	2031	2032	2033	2034	2035
c	0.00037368	0.00033631	0.00030268	0.00027847	0.00025619	0.00023569
d	2.876	2.589	2.330	2.143	1.972	1.814

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[118] The passenger car, light truck, and HDPUV target curve function coefficients are defined in Equation IV–1, Equation IV–2, and Equation IV–3, respectively. See Final TSD Chapter 1.2.1 for a complete discussion about the footprint and work factor curve functions and how they are calculated.

[119] The passenger car, light truck, and HDPUV target curve function coefficients are defined in Equation IV–1, Equation IV–2, and Equation IV–3, respectively. See Final TSD Chapter 1.2.1 for a complete discussion about the footprint and work factor curve functions and how they are calculated.

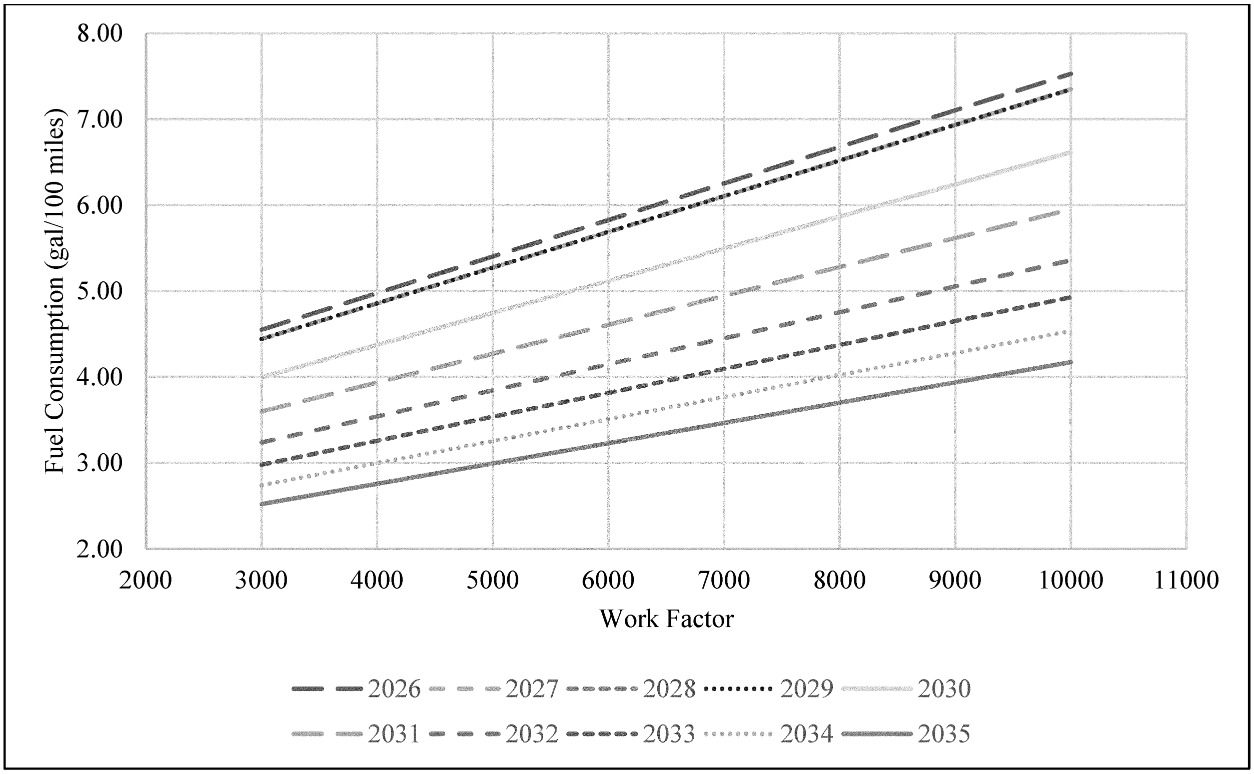

Figure II-4: Final SI Vehicle Standards, Target Curves

E. Final Standards—Impacts

As for past CAFE rulemakings, NHTSA has used the CAFE Model to estimate the effects of this final rule's light duty CAFE and HDPUV fuel efficiency standards and of other regulatory alternatives under consideration. Some inputs to the CAFE Model are derived from other models, such as Argonne National Laboratory's Autonomie vehicle simulation tool and Argonne's GREET fuel-cycle emissions analysis model, the U.S. Energy Information Administration's (EIA's) National Energy Modeling System (NEMS), and EPA's Motor Vehicle Emissions Simulator (MOVES) vehicle emissions model. Especially given the scope of NHTSA's analysis, these inputs involve a number of uncertainties. NHTSA underscores that all results of today's analysis simply represent the agency's best estimates based on the information currently before us and on the agency's reasonable judgment.

1. Light Duty Effects

NHTSA estimates that this final rule would increase the eventual average of manufacturers' CAFE requirements to about 50.4 mpg by 2031 rather than, under the No-Action Alternative (*i.e.,* the baseline standards issued in 2023 ending with model year 2026 standards carried forward indefinitely), about 46.9 mpg. For passenger cars, the standards in 2031 are estimated to require 65.1 mpg, and for light trucks, 45.2 mpg. This compares with 58.8 mpg and 42.6 mpg for cars and trucks, respectively, under the No-Action Alternative.

Table II-4: Estimated Average of CAFE Levels (mpg) Required Under Final Rule

Fleet	2027	2028	2029	2030	2031
Passenger Cars	60.0	61.2	62.5	63.7	65.1
Light Trucks	42.6	42.6	43.5	44.3	45.2
Overall Fleet	47.3	47.4	48.4	49.4	50.4

The model year 2032 augural CAFE standard is estimated to require a fleet average fuel economy of 51.4 mpg rather than, under the No-Action Alternative, about 46.9 mpg. For passenger cars, the average in 2032 is estimated to require 66.4 mpg, and for the light trucks, 46.2 mpg.

Table II-5: Estimated Average Augural CAFE Levels (mpg)

Fleet	2032 (Augural)
Passenger Cars	66.4
Light Trucks	46.2
Overall Fleet	51.4

Because manufacturers do not comply exactly with each standard in each model year, but rather focus their compliance efforts when and where it is most cost-effective to do so, ''estimated achieved'' fuel economy levels differ somewhat from ''estimated required'' levels for each fleet, for each year. NHTSA estimates that the industry-wide average fuel economy achieved in model year 2031 could increase from about 52.1 mpg under the No-Action Alternative to 52.5 mpg under the final rule's standards.

Table II-6: Estimated Average of CAFE Levels (mpg) Achieved Under Final Rule

Fleet	2022	2027	2028	2029	2030	2031
Passenger Cars	47.1	68.6	68.4	68.6	68.6	70.8
Light Trucks	32.1	43.7	44.2	44.9	45.3	46.4
Overall Fleet	36.5	49.9	50.2	50.8	51.1	52.5

The augural achieved CAFE level in model year 2032 is estimated to be 53.5 mpg rather than, under the No-Action Alternative, about 53 mpg. For passenger cars, the fleet average in 2032 is estimated to achieve 72.3 mpg, and for light trucks 47.3 mpg.

Table II-7: Estimated Average Achieved Augural CAFE (mpg)

Fleet	2032 (Augural)
Passenger Cars	72.3
Light Trucks	47.3
Overall Fleet	53.5

NHTSA's analysis estimates manufacturers' potential responses to the combined effect of CAFE standards and separate (reference baseline, model years 2024–2026) CO_2 standards, ZEV programs, and fuel prices. Together, the regulatory programs are more binding (*i.e.,* require more of manufacturers) than any single program considered in isolation, and today's analysis, like past analyses, shows some estimated overcompliance with the final CAFE standards for both the passenger car and light truck fleets.

NHTSA measures and reports benefits and costs from increasing fuel economy and efficiency standards from two different perspectives. First, the agency's ''model year'' perspective focuses on benefits and costs of establishing alternative CAFE standards for model years 2027 through 2031 (and fuel efficiency standards for HDPUVs for model years 2030 through 2035), and measures these over each separate model year's entire lifetime. The calendar year perspective we present includes the annual impacts attributable to all vehicles estimated to be in service in each calendar year for which our analysis includes a representation of the entire registered passenger car, light truck, and HDPUV fleet. For this final rule, this calendar year perspective covers each of calendar years 2022–2050, with differential impacts accruing as early as MY 2022.[120] Compared to the model year perspective, the calendar year perspective includes model years of vehicles produced in the longer term, beyond those model years for which standards are being finalized. The strengths and limitations of each accounting perspective is discussed in detail in FRIA Chapter 5.

The table below summarizes estimates of selected impacts viewed from each of these two perspectives, for each of the regulatory alternatives considered in this final rule, relative to the reference baseline.

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[120] For a presentation of effects by calendar year, please see Chapter 8.2.4.6 of the FRIA.

Table II-8: Selected Cumulative Effects – Passenger Cars and Light Trucks - MY and CY Perspectives[121]

	PC2LT002 (Final Std.)
Avoided Gasoline Consumption (billions gallons)	
MYs 1983-2031	-15.0
CYs 2022-2050	-63.6
Additional Electricity Consumption (TWh)[122]	
MYs 1983-2031	72.8
CYs 2022-2050	333.3

NHTSA estimates for the final standards are compared to levels of gasoline and electricity consumption NHTSA projects would occur under the No-Action Alternative (i.e., the reference baseline) as shown in Table II–8.[123]

NHTSA's analysis also estimates total annual consumption of fuel by the entire on-road light-duty fleet from calendar year 2022 through calendar year 2050. On this basis, gasoline and electricity consumption by the U.S. light-duty vehicle fleet evolves as shown in Figure II–5 and Figure II-6, each of which shows projections for the No-Action Alternative, PC2LT002 (the Preferred Alternative), PC1LT3, PC2LT4, PC3LT5, and PC6LT8.

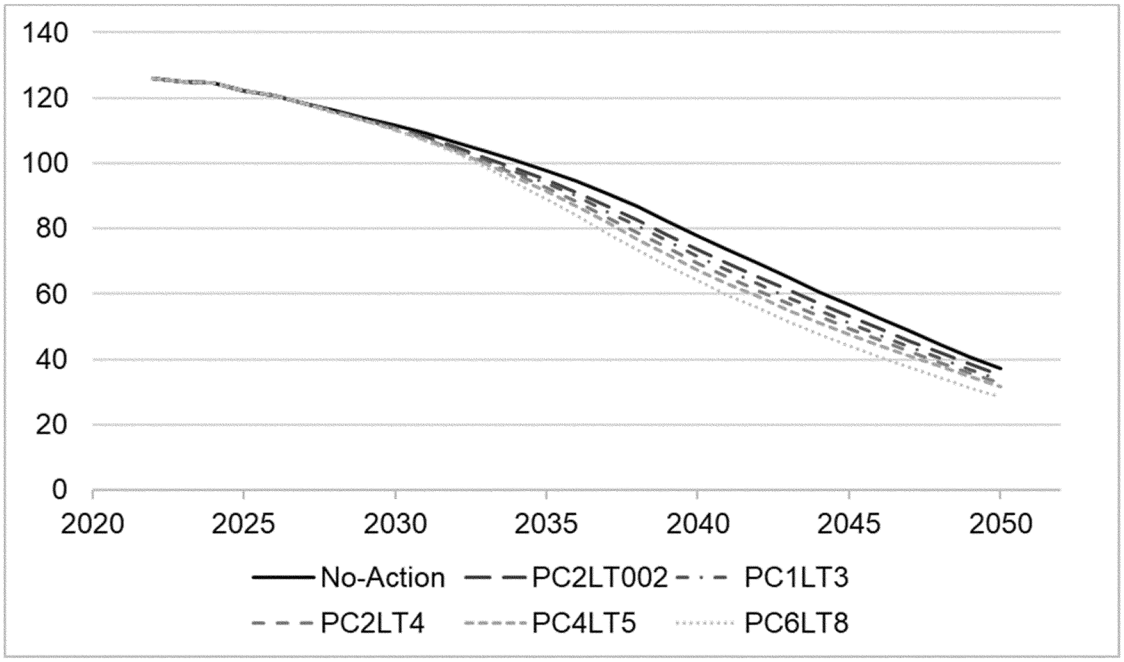

Figure II-5: Estimated Annual Gasoline Consumption by Light-Duty On-Road Fleet (In Billions of Gallons)

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[121] FRIA Chapter 1, Figure 1–1 provides a graphical comparison of energy sources and their relative change over the standard setting years.

[122] The additional electricity use during regulatory years is attributed to an increase in the number of PHEVs; PHEV fuel economy is only considered in charge-sustaining (i.e., gasoline-only) mode in the compliance analysis, but electricity consumption is computed for the effects analysis.

[123] While NHTSA does not condider electrification in its analysis during the rulemaking time frame, the analysis still reflects application of electric vehicles in the baseline fleet and during the model years, such that electrification (and thus, electricity consumption) increases in NHTSA's is not considering it in our decision-making.

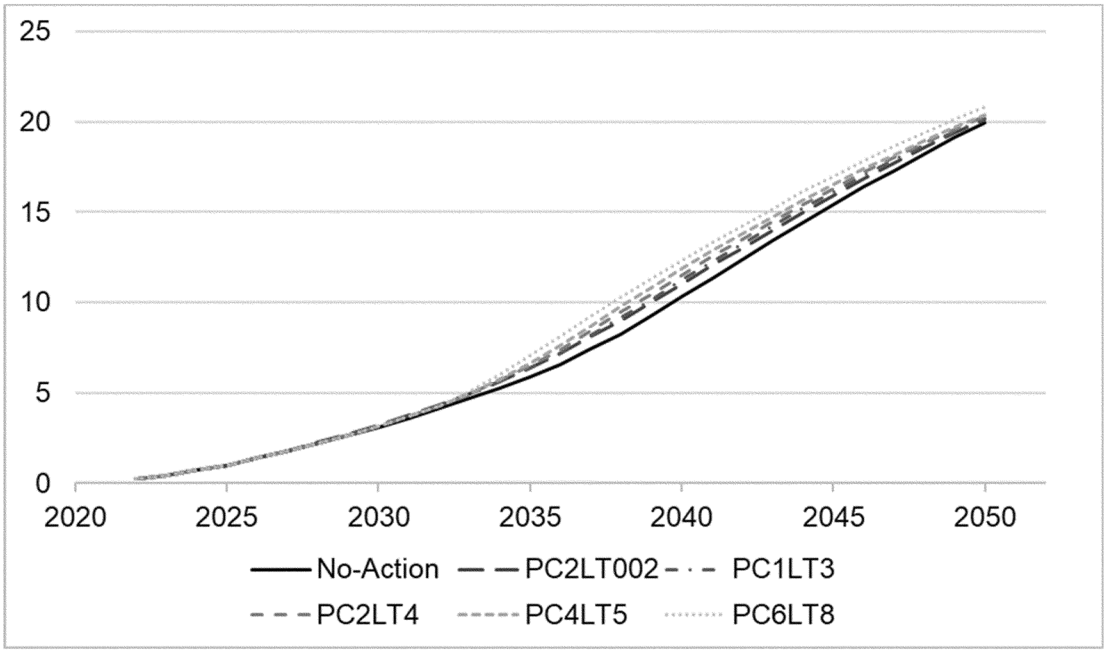

Figure II-6: Estimated Electricity Consumption by Light-Duty On-Road Fleet (In Billions of Gallons)

Accounting for emissions from both vehicles and upstream energy sector processes (*e.g.,* petroleum refining and electricity generation), which are relevant to NHTSA's evaluation of the need of the United States to conserve energy, NHTSA estimates that the final rule would reduce greenhouse gas emissions by about 659 million metric tons of carbon dioxide (CO_2), about 825 thousand metric tons of methane (CH_4), and about 24 thousand metric tons of nitrous oxide (N_2O).

Table II-9: Estimated Changes in Greenhouse Gas Emissions (Metric Tons) vs. No-Action Alternative, CY 2022-2050

Greenhouse Gas	Change in Emissions
Carbon Dioxide (CO_2)	-659 million tons
Methane (CH_4)	-825 thousand tons
Nitrous Oxide (N_2O)	-24 thousand tons

Emissions reductions accrue over time, as the example for CO_2 emissions shows in Figure II–7.

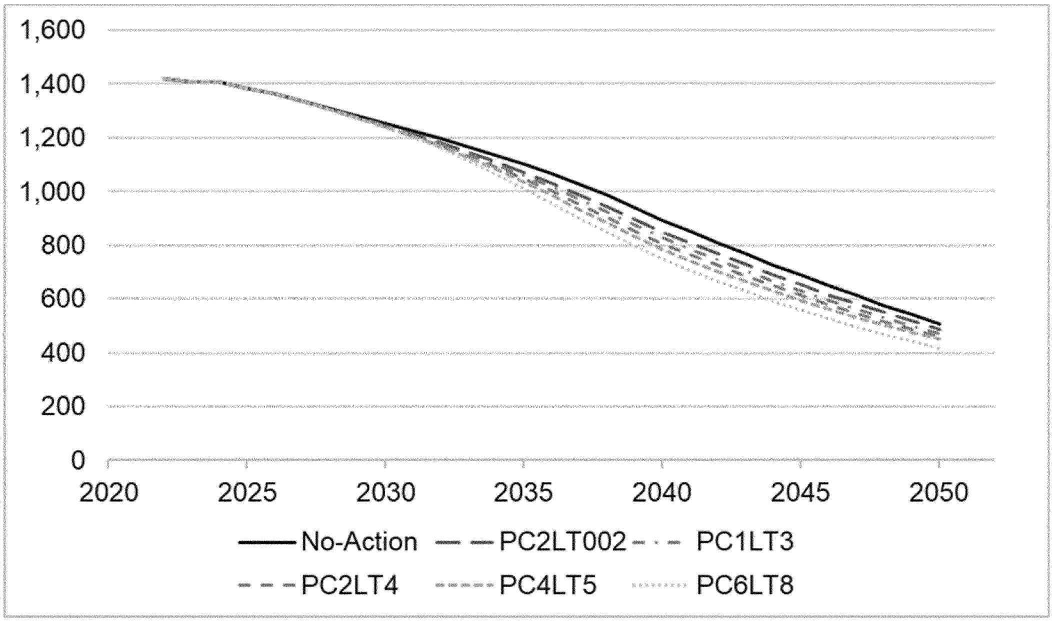

Figure II-7: Estimated Annual CO_2 Emissions Attributable to Light-Duty On-Road Fleet (In Metric Tons)

For the ''standard setting'' analysis, the FRIA accompanying today's notice provides additional detail regarding projected criteria pollutant emissions and health effects, as well as the inclusion of these impacts in today's benefit-cost analysis. For the ''unconstrained'' or ''EIS'' analysis, the Final EIS accompanying today's notice presents much more information regarding projected criteria pollutant emissions, as well as model-based estimates of corresponding impacts on several measures of urban air quality and public health. As mentioned above, these estimates of criteria pollutant emissions are based on a complex analysis involving interacting simulation techniques and a myriad of input estimates and assumptions. Especially extending well past 2050, the analysis involves a multitude of uncertainties.

To illustrate the effectiveness of the technology added in response to today's final rule, Table II–10 presents NHTSA's estimates for increased vehicle cost and lifetime fuel expenditures. For more detailed discussion of these and other results related to LD final standards, see Section V below.

Table II-10: Estimated Impact on Average MY 2031 Vehicle Costs vs. No-Action Alternative, 3 Percent Discount Rate

Consumer Impact	Dollar Value
Range of Price Increases	$392
Lifetime Fuel Savings	$639

With the SC–GHG discounted at 2.0 percent and other benefits and costs discounted at 3 percent, NHTSA estimates that monetized costs and benefits could be approximately $24.5 billion and $59.7 billion, respectively, such that the present value of aggregate monetized net benefits to society could be approximately $35.2 billion. With the SC–GHG discounted at 2.0 percent and other benefits and costs discounted at 7 percent, NHTSA estimates approximately $16.2 billion in monetized costs and $47.0 billion in monetized benefits could be attributable to vehicles produced during and prior to model year 2031 over the course of their lives, such that the present value of aggregate net monetized benefits to society could be approximately $30.8 billion.

Table II-11: Incremental Monetized Benefits and Costs Over the Lifetimes of the LD Fleet Produced Through 2031 (2021$ Billions), by Preferred Alternative, All SC-GHG Levels

	Totals		Annualized	
	3% DR	7% DR	3% DR	7% DR
Total Incremental Social Costs	24.5	16.2	0.96	1.18
Total Incremental Social Benefits				
SC-GHG at 2.5% Discount Rate	47.1	34.5	1.85	2.50
SC-GHG at 2.0% Discount Rate	59.7	47.0	2.34	3.41
SC-GHG at 1.5% Discount Rate	83.2	70.5	3.26	5.12
Total Incremental Net Social Benefits				
SC-GHG at 2.5% Discount Rate	22.7	18.2	0.89	1.32
SC-GHG at 2.0% Discount Rate	35.2	30.8	1.38	2.23
SC-GHG at 1.5% Discount Rate	58.7	54.3	2.30	3.94

Table II-12: Incremental Monetized Benefits and Costs for the LD Fleet CY 2022-2050 (2021$ Billions), Preferred Alternative, All SC-GHG Levels

	Totals		Annualized	
	3% DR	7% DR	3% DR	7% DR
Total Incremental Social Costs	24.5	16.2	0.96	1.18
Total Incremental Social Benefits				
SC-GHG at 2.5% Discount Rate	47.1	34.5	1.85	2.50
SC-GHG at 2.0% Discount Rate	59.7	47.0	2.34	3.41
SC-GHG at 1.5% Discount Rate	83.2	70.5	3.26	5.12
Total Incremental Net Social Benefits				
SC-GHG at 2.5% Discount Rate	22.7	18.2	0.89	1.32
SC-GHG at 2.0% Discount Rate	35.2	30.8	1.38	2.23
SC-GHG at 1.5% Discount Rate	58.7	54.3	2.30	3.94

Table II-13 – Estimated Costs, Benefits, and Net Benefits (2021$ Billions) of the Preferred Alternative for MYs 2027 through 2031, 3% Social Discount Rate, 2.0% SC-GHG Discount Rate

Model Year	Benefit	Cost	Net Benefit
2027	6.3	2.4	3.9
2028	9.3	3.3	6
2029	12.2	4.2	8
2030	14	4.5	9.4
2031	20.7	6.4	14.3
Total	62.5	20.8	41.6

2. Heavy Duty Pickup Trucks and Vans Effects

NHTSA estimates that the final rule would increase HDPUV fuel efficiency standards to about 2.851 gals/100 mile by 2035 rather than, under the No-Action Alternative (*i.e.,* the baseline standards issued in 2016 final rule for Phase 2 ending with model year 2029 standards carried forward indefinitely), about 5.023 gals/100mile. Unlike the light-duty CAFE program, NHTSA may consider AFVs when setting maximum feasible standards for HDPUVs. Additionally, for purposes of calculating average fuel efficiency for HDPUVs, NHTSA considers EVs, fuel cell vehicles, and the proportion of electric operation of EVs and PHEVs that is derived from electricity that is generated from sources that are not onboard the vehicle to have a fuel efficiency value of 0 gallons/mile. NHTSA estimates that the final rule would achieve an average fuel efficiency 2.565 gals/100 mile by 2035 rather than, under the No-Action Alternative, about 2.716 gals/100 mile.

Table II-14: Estimated Average Required and Achieved FE Under Final Rule

Fleet	2022	2030	2031	2032	2033	2034	2035
Overall Fleet Required	5.575	4.503	4.074	3.667	3.373	3.102	2.851
Overall Fleet Achieved	5.896	3.421	2.759	2.758	2.603	2.598	2.565

NHTSA estimates that over the lives of vehicles subject to these final HDPUV standards, the final standards would save about 5.6 billion gallons of gasoline and increase electricity consumption (as the percentage of electric vehicles increases over time) by about 56 TWh (a 5.4 percent increase), compared to levels of gasoline and electricity consumption NHTSA projects would occur under the reference baseline standards (*i.e.,* the No-Action Alternative) as shown in Table II–15.

Table II-15: Estimated Changes in Energy Consumption vs. No-Action Alternative

Energy Source	Change in Consumption
Gasoline	-5.6 billion gallons
Electricity	+56 TWh

NHTSA's analysis also estimates total annual consumption of fuel by the entire on-road HDPUV fleet from calendar year 2022 through calendar year 2050. On this basis, gasoline and electricity consumption by the U.S. HDPUV fleet evolves as shown in Figure II–8 and Figure II–9, each of which shows projections for the No-Action Alternative, HDPUV4, HDPUV108 (the Preferred Alternative), HDPUV10, and HDPUV14.

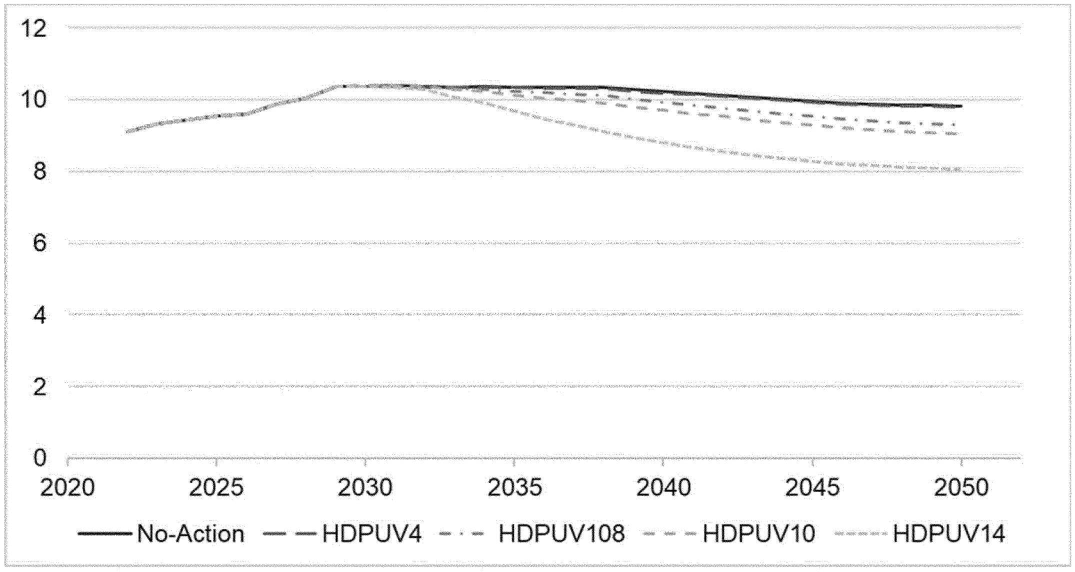

Figure II-8: Total Gasoline Consumption by Calendar Year and Alternative (Billions of Gallons)

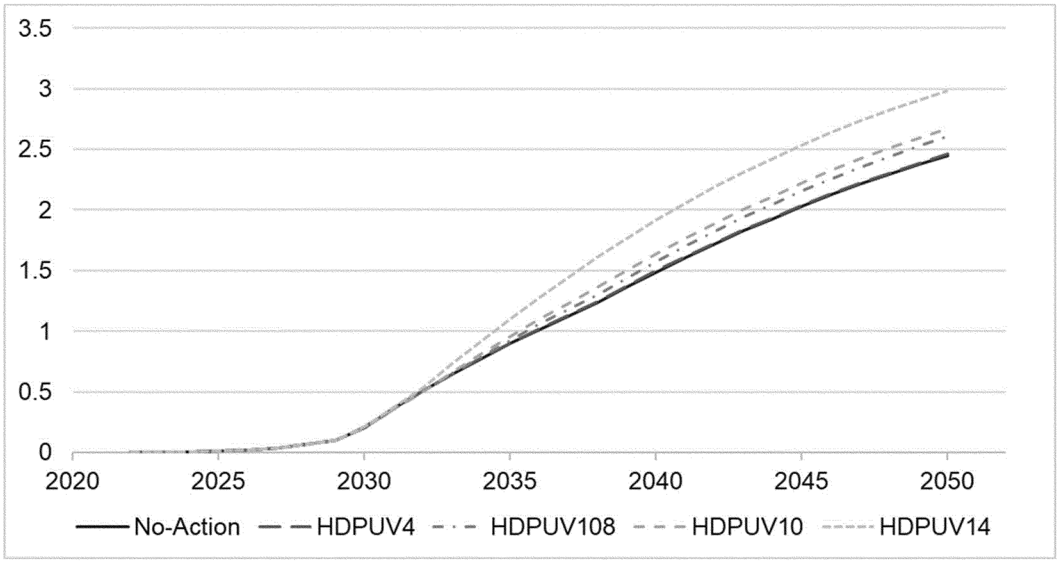

Figure II-9: Total Electricity Consumption by Calendar Year and Alternative (Billions of Gasoline Gallon Equivalents)

Accounting for emissions from both vehicles and upstream energy sector processes (*e.g.,* petroleum refining and electricity generation), which are relevant to NHTSA's evaluation of the need of the United States to conserve energy, NHTSA estimates that the final HDPUV standards would reduce greenhouse gas emissions by about 55 million metric tons of carbon dioxide (CO_2), about 65 thousand metric tons of methane (CH_4), and about 3 thousand metric tons of nitrous oxide (N_2O).

Table II-16: Estimated Changes in Greenhouse Gas Emissions (Metric Tons) vs. No-Action Alternative due to final HDPUV standards, MYs 2030-2035, Total Vehicle Lifetime

Greenhouse Gas	Change in Emissions
Carbon Dioxide (CO_2)	-55 million tons
Methane (CH_4)	-65 thousand tons
Nitrous Oxide (N_2O)	-3 thousand tons

NHTSA's analysis also estimates annual emissions attributable to the entire on-road HDPUV fleet from calendar year 2022 through calendar year 2050. Also accounting for both vehicles and upstream processes, NHTSA estimates that CO_2 emissions from the HDPUV standards could evolve over time as shown in Figure II–10.

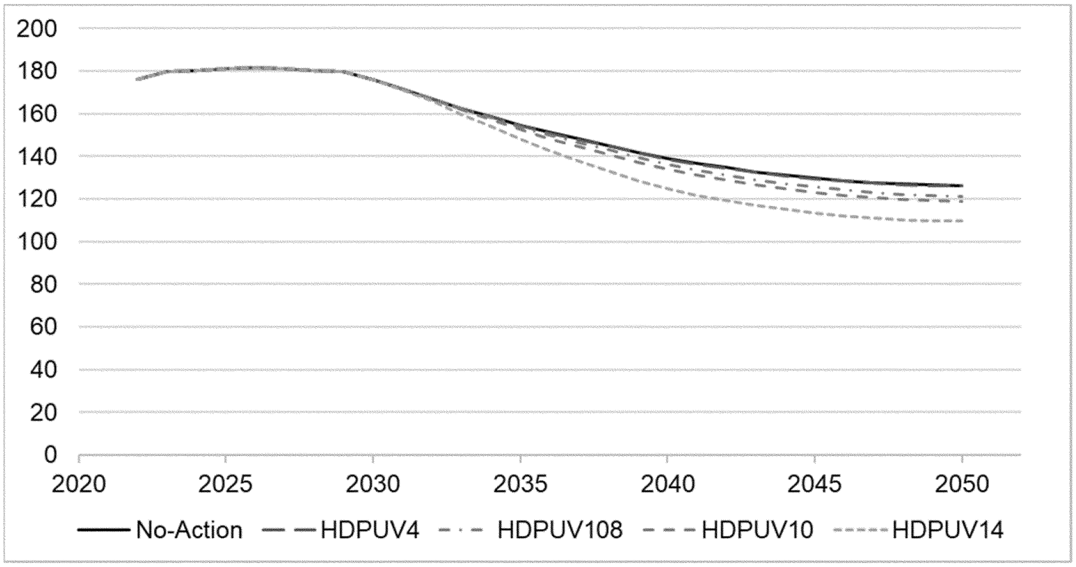

Figure II-10: Total CO_2 Emissions by Calendar Year and Alternative (Millions of Metric Tons)

To illustrate the effectiveness of the technology added to HDPUVs in response to today's final rule and the overall societal effects of the HDPUV standards, Table II–17 presents NHTSA's estimates for increased vehicle cost and lifetime fuel expenditures and Table II–18 summarizes the benefit-cost analysis. For more detailed discussion of these and other results related to HDPUV final standards, see Preamble Section V and Section VI below.

Table II-17: Estimated Impact on Average MY 2038 Vehicle Costs for the HDPUV Preferred Alternative HDPUV 108 vs. No-Action Alternative, 3 Percent Discount Rate

Consumer Impact	Dollar Value
Price Increase	$226
Lifetime Fuel Savings	$717

Table II-18: Incremental Monetized Benefits and Costs for the HDPUV Fleet CY 2022-2050 (2021$ Billions), Preferred Alternative, All SC-GHG Levels

	Totals		Annualized	
	3% DR	7% DR	3% DR	7% DR
Total Incremental Social Costs	3.4	1.6	0.18	0.13
Total Incremental Social Benefits				
SC-GHG at 2.5% Discount Rate	12.6	9.0	0.66	0.73
SC-GHG at 2.0% Discount Rate	17.0	13.4	0.89	1.09
SC-GHG at 1.5% Discount Rate	25.3	21.7	1.32	1.76
Total Incremental Net Social Benefits				
SC-GHG at 2.5% Discount Rate	9.2	7.4	0.48	0.60
SC-GHG at 2.0% Discount Rate	13.6	11.8	0.71	0.96
SC-GHG at 1.5% Discount Rate	21.9	20.1	1.14	1.64

F. Final Standards Are Maximum Feasible

NHTSA's conclusion, after consideration of the factors described below and information in the administrative record for this action, is that 2 percent increases in stringency for passenger cars for model years 2027–2031, 0 percent increases in stringency for light trucks in model years 2027–2028, and 2 percent increases in stringency for model years 2029–2031 for light trucks (Alternative PC2LT002) are maximum feasible. The Department of Transportation is deeply committed to working aggressively to improve energy conservation and reduce environmental harms and economic and security risks associated with energy use. NHTSA has concluded that Alternative PC2LT002 is technologically feasible, is economically practicable (based on manageable average per-vehicle cost increases, minimal effects on sales, and estimated increases in employment, among other considerations), and is complementary to other motor vehicle standards of the Government on fuel economy that are simultaneously applicable during model years 2027–2031, as described in more detail below.

After consideration of the technical capabilities, economic practicability, statutory requirements, and the Phase 2 final standards, NHTSA has concluded that a 10 percent increase in model years 2030–2032 and an 8 percent increase in model years 2033–2035 for the HDPUV fleet (HDPUV108) is maximum feasible. NHTSA's analysis shows that current Phase 2 standards do not require significant technological improvements through model year 2029, though we expect to see additional fuel efficient technology penetration in model years 2030 through 2035, which can be viewed in more detail in FRIA Chapter 8. Considering our statutory requirements, we have reduced the stringency to 8 percent increases in model years 2033–2035.

See preamble Section VI for more discussion on how we determined that the final CAFE and HDPUV standards are maximum feasible.

G. Final Standards Are Feasible in the Context of EPA's Final Standards and California's Standards

The NHTSA and EPA final rules remain coordinated despite being issued as separate regulatory actions. NHTSA is finalizing CAFE standards that represent the maximum feasible under our program's statutory constraints, which differ to varying degrees by vehicle classification and model year from the GHG standards set forth by the EPA. Overall, EPA's GHG standards, developed under their program's authorities, place a higher degree of stringency on manufacturers in part because of their ability to consider all vehicle technologies, including alternative fueled vehicles, in setting standards. As with past rules, NHTSA's and EPA's programs also differ in other respects, such as programmatic flexibilities. Accordingly, NHTSA's coordination with EPA was limited to areas where each agency's statutory framework allowed some level of harmonization. These differences mean that manufacturers have had (and will continue to have) to plan their compliance strategies considering both the CAFE standards and the GHG standards to ensure that they maintain compliance with both. Because NHTSA and EPA are regulating the same vehicles and manufacturers will use many of the same technologies to meet each set of standards, NHTSA performed appropriate analyses to quantify the differences and their impacts. Auto manufacturers have shown a consistent historical ability to manage compliance strategies that account for the concurrent implementation of multiple regulatory programs. Past experience with these programs indicates that each manufacturer will optimize its compliance strategy around whichever standard is most binding for its fleet of vehicles. If different agencies' standards are more binding for some companies in certain years, this does not mean that manufacturers must build multiple fleets of vehicles, but rather that they will have to be more strategic about how they build their fleet. More detailed discussion of this issue can be found in Section VI.A of this preamble. Critically, NHTSA has concluded that it is feasible for manufacturers to meet the NHTSA standards in a regulatory framework that includes the EPA standards.

NHTSA has also considered and accounted for manufacturers' expected compliance with California's ZEV program (ACC I and ACT) and its adoption by other states in developing the reference baseline for this final rule. We have also accounted for the Framework Agreements between manufacturers who have committed to meeting those Agreements. Finally, we accounted for additional ZEV deployment that manufacturers have committed to undertake, which would be consistent with the requirements of ACC II. NHTSA's assessment regarding the inclusion of ZEVs in the reference baseline is detailed in Preamble Section III.C.5 and Section IV.B.1, and well as in Chapter 3.1 of the accompanying FRIA.

NHTSA also conducted an analysis using an alternative baseline, under which NHTSA removed not only the electric vehicles that would be deployed to comply with ACC I, but also those that would be deployed consistent with manufacturer commitments to deploy additional electric vehicles regardless of legal requirements, consistent with the levels under ACC II. NHTSA describes this as the ''No ZEV alternative baseline.'' For further reading on this alternative baseline, see RIA Chapters 3 and 8 and Preamble Section IV.B for comparison of the baselines.

III. Technical Foundation for Final Rule Analysis

A. Why is NHTSA conducting this analysis?

NHTSA is finalizing CAFE standards that will increase at 2 percent per year for passenger cars during MYs 2027 through 2031, and for light trucks, standards that will not increase beyond the MY 2026 standards in MYs 2027 through 2028, thereafter increasing at 2 percent per year for MYs 2029 through 2031. The final HDPUV standards will increase at 10 percent per year during MYs 2030 through 2032, and then increase at 8 percent for MYs 2033 through 2035. NHTSA estimates these stringency increases in the passenger car and light truck fleets will reduce gasoline consumption through calendar year 2050 by about 64 billion gallons and increase electricity consumption by about 333 terawatt-hours (TWh). The stringency increases in the HDPUV fleet will reduce gasoline consumption by about 5.6 billion gallons and increase electricity consumption by about 56 TWh through calendar year 2050. Accounting for emissions from both vehicles and upstream energy sector processes (*e.g.,* petroleum refining and electricity generation), NHTSA estimates that the CAFE standards will reduce greenhouse gas emissions by about 659 million metric tons of carbon dioxide (CO_2), about 825 thousand metric tons of methane (CH_4), and about 23.5 thousand metric tons of nitrous oxide (N_20). The HDPUV standards are estimated to further reduce greenhouse gas emissions by 55 million metric tons of CO_2, 65 thousand metric tons of CH_4 and 3 thousand metric tons of N_20.

When NHTSA promulgates new regulations, it generally presents an analysis that estimates the impacts of those regulations, and the impacts of other regulatory alternatives. These analyses derive from statutes such as the Administrative Procedure Act (APA) and NEPA, from E.O.s (such as E.O. 12866 and 13563), and from other administrative guidance (*e.g.,* Office of Management and Budget (OMB) Circular A–4). For CAFE and HDPUV standards, EPCA, as amended by EISA, contains a variety of provisions that NHTSA seeks to account for analytically. Capturing all of these requirements analytically means that NHTSA presents an analysis that spans a meaningful range of regulatory alternatives, that quantifies a range of technological, economic, and environmental impacts, and that does so in a manner that accounts for EPCA/EISA's various express requirements for the CAFE and HDPUV programs (*e.g.,* passenger cars and light trucks must be regulated separately; the standard for each fleet must be set at the maximum feasible level in each MY; etc.).

NHTSA's standards are thus supported by, although not dictated by, extensive analysis of potential impacts of the regulatory alternatives under consideration. Together with this preamble, a TSD, a FRIA, and a Final EIS, provide a detailed enumeration of related methods, estimates, assumptions, and results. These additional analyses can be found in the rulemaking docket for this final rule[124] and on NHTSA's website.[125]

This section provides further detail on the key features and components of NHTSA's analysis. It also describes how NHTSA's analysis has been constructed specifically to reflect governing law applicable to CAFE and HDPUV standards (which may vary between programs). Finally, the discussion reviews how NHTSA's analysis has been expanded and improved in response to comments received on the 2023 proposal,[126] as well as additional work conducted over the last year. The analysis for this final rule aided NHTSA in implementing its statutory obligations, including the weighing of various considerations, by reasonably informing decision-makers about the estimated effects of choosing different regulatory alternatives.

1. What are the key components of NHTSA's analysis?

NHTSA's analysis makes use of a range of data (*i.e.,* observations of things that have occurred), estimates (*i.e.,* things that may occur in the future), and models (*i.e.,* methods for making estimates). Two examples of *data* include (1) records of actual odometer readings used to estimate annual mileage accumulation at different vehicle ages and (2) CAFE compliance data used as the foundation for the ''analysis fleets'' containing, among other things, production volumes and fuel economy/fuel efficiency levels of specific configurations of specific vehicle models produced for sale in the U.S. Two examples of *estimates* include (1) forecasts of future Gross Domestic Product (GDP) growth used, with other estimates, to forecast future vehicle sales volumes and (2) technology cost estimates, which include estimates of the technologies' ''direct cost,'' marked up by a ''retail price equivalent'' (RPE) factor used to estimate the ultimate cost to consumers of a given fuel-saving technology, and an estimate of ''cost learning effects'' (*i.e.,* the tendency that it will cost a manufacturer less to apply a technology as the manufacturer gains more experience doing so).

NHTSA uses the CAFE Compliance and Effects Modeling System (usually shortened to the ''CAFE Model'') to estimate manufacturers' potential responses to new CAFE, HDPUV, and GHG standards and to estimate various impacts of those responses. DOT's Volpe National Transportation Systems Center (often simply referred to as the ''Volpe Center'') develops, maintains, and applies the model for NHTSA. NHTSA has used the CAFE Model to perform analyses supporting every CAFE rulemaking since 2001. The 2016 rulemaking regarding HDPUV fuel efficiency standards, NHTSA's most recent HDPUV rulemaking, also used the CAFE Model for analysis.

The basic design of the CAFE Model is as follows: The system first estimates how vehicle manufacturers might respond to a given regulatory scenario, and from that potential compliance solution, the system estimates what impact that response will have on fuel consumption, emissions, safety impacts, and economic externalities. In a highly summarized form, TSD Figure 1–1 shows the basic categories of CAFE Model procedures and the sequential logical flow between different stages of the modeling.[127] The diagram does not present specific model inputs or

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[124] Docket No. NHTSA–2023–0022, which can be accessed at *https://www.regulations.gov.*

[125] See NHTSA. 2023. Corporate Average Fuel Economy. Available at: *https://www.nhtsa.gov/laws-regulations/corporate-average-fuel-economy.* (Accessed: Feb. 23, 2024).

[126] 88 FR 56128 (Aug. 17, 2023).

[127] TSD Chapter 1, see Figure 1–1: CAFE Model Procedures and Logical Flow.

outputs, as well as many specific procedures and model interactions. The model documentation accompanying this final rule presents these details.[128]

More specifically, the model may be characterized as an integrated system of models. For example, one model estimates manufacturers' responses, another estimates resultant changes in total vehicle sales, and still another estimates resultant changes in fleet turnover (*i.e.,* scrappage). Additionally, and importantly, the model does not determine the form or stringency of the standards. Instead, the model applies inputs specifying the form and stringency of standards to be analyzed and produces outputs showing the impacts of manufacturers working to meet those standards, which become part of the basis for comparing different potential stringencies. A regulatory scenario, meanwhile, involves specification of the form, or shape, of the standards (*e.g.,* flat standards, or linear or logistic attribute-based standards), scope of passenger car, light truck, and HDPUV regulatory classes, and stringency of the CAFE or HDPUV standards for each MY to be analyzed. For example, a regulatory scenario may define CAFE or HDPUV standards for a particular class of vehicles that increase in stringency by a given percent per year for a given number of consecutive years.

Manufacturer compliance simulation and the ensuing effects estimation, collectively referred to as compliance modeling, encompass numerous subsidiary elements. Compliance simulation begins with a detailed user-provided initial forecast of the vehicle models offered for sale during the simulation period.[129] The compliance simulation then attempts to bring each manufacturer into compliance with the standards defined by the regulatory scenario contained within an input file developed by the user.[130]

Estimating impacts involves calculating resultant changes in new vehicle costs, estimating a variety of costs (*e.g.,* for fuel) and effects (*e.g.,* CO_2 emissions from fuel combustion) occurring as vehicles are driven over their lifetimes before eventually being scrapped, and estimating the monetary value of these effects. Estimating impacts also involves consideration of consumer responses—*e.g.,* the impact of vehicle fuel economy/efficiency, operating costs, and vehicle price on consumer demand for passenger cars, light trucks, and HDPUVs. Both basic analytical elements involve the application of many analytical inputs. Many of these inputs are developed outside of the model and not by the model. For example, the model applies fuel prices; it does not estimate fuel prices.

NHTSA also uses EPA's Motor Vehicle Emission Simulator (MOVES) model to estimate ''vehicle'' or ''downstream'' emission factors for criteria pollutants,[131] and uses four Department of Energy (DOE) and DOE-sponsored models to develop inputs to the CAFE Model, including three developed and maintained by DOE's Argonne National Laboratory (Argonne). The agency uses the DOE Energy Information Administration's (EIA's) National Energy Modeling System (NEMS) to estimate fuel prices,[132] and uses Argonne's Greenhouse gases, Regulated Emissions, and Energy use in Transportation (GREET) model to estimate emissions rates from fuel production and distribution processes.[133] DOT also sponsored DOE/Argonne to use Argonne's Autonomie full-vehicle modeling and simulation system to estimate the fuel economy/efficiency impacts for over a million combinations of technologies and vehicle types.[134] The TSD and FRIA describe details of our use of these models. In addition, as discussed in the Final EIS accompanying this final rule, DOT relied on a range of models to estimate impacts on climate, air quality, and public health. The Final EIS discusses and describes the use of these models.

To prepare for the analysis that supports this final rule, DOT has refined and expanded the CAFE Model through ongoing development. Examples of such changes, some informed by past external comment, made since 2022 include:[135]

- Updated analysis fleet
- Addition of HDPUVs, and associated required updates across entire model
- Updated technologies considered in the analysis
  - ○ Addition of HCRE, HCRD and updated diesel technology models[136]
  - ○ Removal of EFR, DSLIAD, manual transmissions, AT6L2, EPS, IACC, LDB, SAX, and some P2 combinations[137]
- User control of additional input parameters
- Updated modeling approach to manufacturers' expected compliance with states' ZEV programs
- Expanded accounting for Federal incentives, such as the IRA
- Expanded procedures for estimating new vehicle sales and fleet shares
- VMT coefficient updates

In response to feedback, interagency meetings, comments from stakeholders, as well as continued development, DOT has made additional changes to the CAFE Model for the final rule. Since the 2023 NPRM, DOT has made the following changes to the CAFE Model and inputs, including:[138]

- Updated battery costs for electrified technologies
- Updated different phase-in penetration for different BEV ranges
- Updated ZEV State shares, credit values and projected ZEV requirements to inform the reference baseline
- Reclassified Rivian and Ford vehicles from HDPUV to LD based on official certification data submission
- Allow the user to directly input AC efficiency, AC leakage and off cycle credit limits for each MY, separately for conventional ICE vehicles and electric vehicles
- Addressed issues with when road load technologies are applied to the fleet

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[128] CAFE Model Documentation for 2024 FRM.

[129] Because the CAFE Model is publicly available, anyone can develop their own initial forecast (or other inputs) for the model to use. The DOT-developed Market Data Input file that contains the forecast for this final rule is available on NHTSA's website at *https://www.nhtsa.gov/corporate-average-fuel-economy/cafe-compliance-and-effects-modeling-system.*

[130] With appropriate inputs, the model can also be used to estimate impacts of manufacturers' potential responses to new CO_2 standards and to California's ZEV program.

[131] See *https://www.epa.gov/moves.* This final rule uses version MOVES4 (the latest version at the time of analysis), available at *https://www.epa.gov/moves/latest-version-motor-vehicle-emission-simulator-moves.*

[132] See *https://www.eia.gov/outlooks/aeo/.* This final rule uses fuel prices estimated using the Annual Energy Outlook (AEO) 2023 version of NEMS (see *https://www.eia.gov/outlooks/aeo/tables_ref.php.*).

[133] Information regarding GREET is available at *https://greet.es.anl.gov/.* This final rule uses the R&D GREET 2023 version.

[134] As part of the Argonne simulation effort, individual technology combinations simulated in Autonomie were paired with Argonne's BatPaC model to estimate the battery cost associated with each technology combination based on characteristics of the simulated vehicle and its level of electrification. Information regarding Argonne's BatPaC model is available at *https://www.anl.gov/cse/batpac-model-software.* In addition, the impact of engine technologies on fuel consumption, torque, and other metrics was characterized using GT–POWER simulation modeling in combination with other engine modeling that was conducted by IAV Automotive Engineering, Inc. (IAV). The engine characterization ''maps'' resulting from this analysis were used as inputs for the Autonomie full-vehicle simulation modeling. Information regarding GT–POWER is available at *https://www.gtisoft.com/gt-power/.*

[135] A more detailed list can be found in Chapter 1.1 of the TSD.

[136] See technologies descriptions in TSD Chapter 3.

[137] See technologies description in 87 FR 25710 (May 2, 2022).

[138] A more detailed list of updates can be found in Chapter 1.1 of the TSD.

- Updated and expanded model reporting capabilities
- Updated IRA Tax Credit implementation
- Updated input factors for economic models
- Updated input factors for the safety models
- Updated emission modeling

These changes reflect DOT's long-standing commitment to ongoing refinement of its approach to estimating the potential impacts of new CAFE and HDPUV standards.[139] The TSD elaborates on these changes to the CAFE Model, as well as changes to inputs to the model for this analysis.

NHTSA underscores that this analysis uses the CAFE Model in a manner that explicitly accounts for the fact that in producing a single fleet of vehicles for sale in the United States, manufacturers make decisions that consider the combination of CAFE/HDPUV standards, EPA GHG standards, and various policies set at sub-national levels (*e.g.,* ZEV regulatory programs, set by California and adopted by many other states). These regulations have important structural and other differences that affect the strategy a manufacturer could pursue in designing a fleet that complies with each of the above. As explained, NHTSA's analysis reflects a number of statutory and regulatory requirements applicable to CAFE/HDPUV and EPA GHG standard-setting. As stated previously, NHTSA coordinated with EPA and DOE to optimize the effectiveness of NHTSA's standards while minimizing compliance costs, informed by public comments from all stakeholders and consistent with the statutory factors.

2. How do requirements under EPCA/EISA shape NHTSA's analysis?

EPCA contains multiple requirements governing the scope and nature of CAFE standard setting. Some of these have been in place since EPCA was first signed into law in 1975, and some were added in 2007, when Congress passed EISA and amended EPCA. EISA also gave NHTSA authority to set standards for HDPUVs, and that authority was generally less constrained than for CAFE standards. NHTSA's modeling and analysis to inform standard setting is guided and shaped by these statutory requirements. EPCA/EISA requirements regarding the technical characteristics of CAFE and HDPUV standards and the analysis thereof include, but are not limited to, the following:

Corporate Average Standards: Section 32902 of 49 U.S.C. requires standards for passenger cars, light trucks, and HDPUVs to be corporate average standards, applying to the average fuel economy/efficiency levels achieved by each corporation's fleets of vehicles produced for sale in the U.S.[140] The CAFE Model calculates the CAFE and CO_2 levels of each manufacturer's fleets based on estimated production volumes and characteristics, including fuel economy/efficiency levels, of distinct vehicle models that could be produced for sale in the U.S.

Separate Standards for Passenger Cars, Light Trucks, and HDPUVs: Section 32902 of 49 U.S.C. requires the Secretary of Transportation to set CAFE standards separately for passenger cars and light trucks and allows the Secretary to prescribe separate standards for different classes of heavy-duty (HD) vehicles like HDPUVs. The CAFE Model accounts separately for differentiated standards and compliance pathways for passenger cars, light trucks, and HDPUVs when it analyzes CAFE/HDPUV or GHG standards.

Attribute-Based Standards: Section 32902 of 49 U.S.C. requires the Secretary of Transportation to define CAFE standards as mathematical functions expressed in terms of one or more vehicle attributes related to fuel economy, and NHTSA has extended this approach to HDPUV standards as well through regulation. This means that for a given manufacturer's fleet of vehicles produced for sale in the U.S. in a given regulatory class and MY, the applicable minimum CAFE requirement (or maximum HDPUV fuel consumption requirement) is computed based on the applicable mathematical function, and the mix and attributes of vehicles in the manufacturer's fleet. The CAFE Model accounts for such functions and vehicle attributes explicitly.

Separately Defined Standards for Each Model Year: Section 32902 of 49 U.S.C. requires the Secretary of Transportation (by delegation, NHTSA) to set CAFE standards (separately for passenger cars and light trucks) [141] at the maximum feasible levels in each MY. Fuel efficiency levels for HDPUVs must also be set at the maximum feasible level, in tranches of (at least) 3 MYs at a time. The CAFE Model represents each MY explicitly, and accounts for the production relationships between MYs.[142]

Separate Compliance for Domestic and Imported Passenger Car Fleets: Section 32904 of 49 U.S.C. requires the EPA Administrator to determine CAFE compliance separately for each manufacturer's fleets of domestic passenger cars and imported passenger cars, which manufacturers must consider as they decide how to improve the fuel economy of their passenger car fleets.[143] The CAFE Model accounts explicitly for this requirement when simulating manufacturers' potential responses to CAFE standards, and combines any given manufacturer's domestic and imported cars into a single fleet when simulating that manufacturer's potential response to GHG standards (because EPA does not have separate standards for domestic and imported passenger cars).

Minimum CAFE Standards for Domestic Passenger Car Fleets: Section 32902 of 49 U.S.C. requires that domestic passenger car fleets meet a minimum standard, which is calculated as 92 percent of the industry-wide average level required under the applicable attribute-based CAFE standard, as projected by the Secretary at the time the standard is promulgated. The CAFE Model accounts explicitly for this requirement when simulating manufacturer compliance with CAFE standards and sets this requirement aside when simulating manufacturer compliance with GHG standards.

Civil Penalties for Noncompliance: Section 32912 of 49 U.S.C. (and implementing regulations) prescribes a rate (in dollars per tenth of a mpg) at which the Secretary is to levy civil penalties if a manufacturer fails to comply with a passenger car or light truck CAFE standard for a given fleet in a given MY, after considering available credits. Some manufacturers have historically chosen to pay civil penalties rather than achieve full numerical compliance across all fleets.[144] The

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[139] A list accounting of major updates since the CAFE Model was developed in 2001 can be found in Chapter 1.1 of the TSD.

[140] This differs from certain other types of vehicle standards, such as safety standards. For example, every vehicle produced for sale in the U.S. must, on its own, meet all applicable Federal motor vehicle safety standards (FMVSS), but no vehicle produced for sale must, on its own, meet Federal fuel economy or efficiency standards. Rather, each manufacturer is required to produce a mix of vehicles that, taken together, achieve an average fuel economy/efficiency level no less than the applicable minimum level.

[141] Chaper 329 of title 49 of the U.S. Code uses the term ''non-passenger automobiles,'' while NHTSA uses the term ''light trucks'' in its CAFE regulations. The terms' meanings are identical.

[142] For example, a new engine first applied to a given mode/configuration in MY 2027 will most likely persist in MY 2028 of that same vehicle model/configuration, in order to reflect the fact that manufacturers do not apply brand-new engines to a given vehicle model every single year. The CAFE Model is designed to account for these real-world factors.

[143] There is no such requirement for light trucks or HDPUVs.

[144] NHTSA does not assume willingness to pay civil penalties for manufacturers who have commented publicly that they will not pay civil

CAFE Model calculates civil penalties (adjusted for inflation) for CAFE shortfalls and provides means to estimate that a manufacturer might stop adding fuel-saving technologies once continuing to do so would effectively be more ''expensive'' (after accounting for fuel prices and buyers' willingness to pay for fuel economy) than paying civil penalties. The CAFE Model does not allow civil penalty payment as an option for EPA's GHG standards or NHTSA's HDPUV standards.[145]

Dual-Fueled and Dedicated Alternative Fuel Vehicles: For purposes of calculating passenger car and light truck CAFE levels used to determine compliance, 49 U.S.C. 32905 and 32906 specify methods for calculating the fuel economy levels of vehicles operating on alternative fuels to gasoline or diesel, such as electricity. In some cases, after MY 2020, methods for calculating AFV fuel economy are governed by regulation. The CAFE Model can account for these requirements explicitly for each vehicle model. However, 49 U.S.C. 32902 prohibits consideration of the fuel economy of dedicated Alternative Fuel Vehicles (AFVs), and requires that the fuel economy of dual-fueled AFVs' fuel economy, such as plug-in electric vehicles (EVs), be calculated as though they ran only on gasoline or diesel, when NHTSA determines the maximum feasible fuel economy level that manufacturers can achieve, in a given year for which NHTSA is establishing CAFE standards. The CAFE Model therefore has an option to be run in a manner that excludes the additional application of dedicated AFVs and counts only the gasoline fuel economy of dual-fueled AFVs, in MYs for which maximum feasible standards are under consideration. As allowed under NEPA for analysis appearing in Environmental Impact Statements (EIS) that help inform decision makers about the environmental impacts of CAFE standards, the CAFE Model can also be run without this analytical constraint. The CAFE Model does account for dedicated and dual-fueled AFVs when simulating manufacturers' potential responses to EPA's GHG standards because the Clean Air Act (CAA), under which the EPA derives its authority to set GHG standards for motor vehicles, contains no restrictions in using AFVs for compliance. There are no specific statutory directions in EISA with regard to dedicated and dual-fueled AFV fuel efficiency for HDPUVs, so the CAFE Model reflects relevant regulatory provisions by calculating fuel consumption directly per 49 U.S.C. 32905 and 32906 specified methods.

ZEV Regulatory Programs: The CAFE Model can simulate manufacturers' compliance with state-level ZEV programs applicable in California and ''Section 177'' [146] states. This approach involves identifying specific vehicle model/configurations that could be replaced with BEVs and converting to BEVs only enough sales count of the vehicle models to meet the manufacturer's compliance obligations under state-level ZEV programs, before beginning to consider the potential that other technologies could be applied toward compliance with CAFE, HDPUV, or GHG standards.

Creation and Use of Compliance Credits: Section 32903 of 49 U.S.C. provides that manufacturers may earn CAFE ''credits'' by achieving a CAFE level beyond that required of a given passenger car or light truck fleet in a given MY and specifies how these credits may be used to offset the amount by which a different fleet falls short of its corresponding requirement. These provisions allow credits to be ''carried forward'' and ''carried back'' between MYs, transferred between regulated classes (domestic passenger cars, imported passenger cars, and light trucks), and traded between manufacturers. However, credit use for passenger car and light truck compliance is also subject to specific statutory limits. For example, CAFE compliance credits can be carried forward a maximum of five MYs and carried back a maximum of three MYs. Also, EPCA/EISA caps the amount of credits that can be transferred between passenger car and light truck fleets and prohibits manufacturers from applying traded or transferred credits to offset a failure to achieve the applicable minimum standard for domestic passenger cars. The CAFE Model can simulate manufacturers' potential use of CAFE credits carried forward from prior MYs or transferred from other fleets.[147] Section 32902 of 49 U.S.C. prohibits consideration of manufacturers' potential application of CAFE compliance credits when determining the maximum feasible fuel economy level that manufacturers can achieve for their fleets of passenger cars and light trucks. The CAFE Model can be operated in a manner that excludes the application of CAFE credits for a given MY under consideration for standard setting, and NHTSA operated the model with that constraint for the purpose of determining the appropriate CAFE standard for passenger cars and light trucks. No such statutory restrictions exist for setting HDPUV standards. For modeling EPA's GHG standards, the CAFE Model does not limit transfers because the CAA does not limit them. Insofar as the CAFE Model can be exercised in a manner that simulates trading of GHG compliance credits, such simulations treat trading as unlimited.[148]

Statutory Basis for Stringency: Section 32902 of 49 U.S.C. requires the Secretary of Transportation (by delegation, NHTSA) to set CAFE standards for passenger cars and light trucks at the maximum feasible levels that manufacturers can achieve in a given MY, considering technological feasibility, economic practicability, the need of the United States to conserve energy, and the impact of other motor vehicle standards of the Government on fuel economy. For HDPUV standards, which must also achieve the maximum

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penalties in the rulemaking time frame, MY 2027 to MY 2031.

[145] While civil penalties are an option in the HDPUV fleet manufacturers have not exercised this option in the real world. Additionally, the penalties for noncompliance are significantly higher, and thus manufacturers will try to avoid paying them. Setting the model to disallow civil penalties acts to best simulate this behavior. If the model does find no option other than ''paying a civil penalty'' in the HDPUV fleet, this cost should be considered a proxy for credit purchase.

[146] The term ''Section 177'' states refers to states which have elected to adopt California's standards in lieu of Federal requirements, as allowed under section 177 of the CAA.

[147] The CAFE Model does not explicitly simulate the potential that manufacturers would carry CAFE or GHG credits back (*i.e.,* borrow) from future model years, or acquire and use CAFE compliance credits from other manufacturers. At the same time, because EPA has elected not to limit credit trading, the CAFE Model can be exercised (for purposes of evaluating GHG standards) in a manner that simulates unlimited (a.k.a. ''perfect'') GHG compliance credit trading throughout the industry (or, potentially, within discrete trading ''blocs''). Given these dynamics, and given also the fact that the agency has yet to resolve some of the analytical challenges associated with simulating use of these flexibilities, the agency has decided to support this final rule with a conservative analysis that sets aside the potential that manufacturers would depend widely on borrowing and trading—not to mention that, for purposes of determining maximum feasible CAFE standards, statute prohibits NHTSA from considering the trading, transferring, or availability of credits (*see* 49 U.S.C. 32902(h)). While compliance costs in real life may be somewhat different from what is modeled in the rulemaking record as a result of this decision, that is broadly true no matter what, and the agency does not believe that the difference would be so great that it would change the policy outcome. Furthermore, a manufacturer employing a trading strategy would presumably do so because it represents a lower-cost compliance option. Thus, the estimates derived from this modeling approach are likely to be conservative in this respect, with real-world compliance costs likely being lower.

[148] To avoid making judgments about possible future trading activity, the model simulates trading by combining all manufacturers into a single entity, so that the most cost-effective choices are made for the fleet as a whole.

feasible improvement, the similar yet distinct factors of appropriateness, cost-effectiveness, and technological feasibility must be considered. EPCA/EISA authorizes the Secretary of Transportation (by delegation, NHTSA) to interpret these factors, and as the Department's interpretation has evolved, NHTSA has continued to expand and refine its qualitative and quantitative analysis to account for these statutory factors. For example, one of the ways that economic practicability considerations are incorporated into the analysis is through the technology effectiveness determinations: the Autonomie simulations reflect the agency's conservative assumption that it would not be economically practicable (nor, for HDPUVs, appropriate for vehicles with different use cases) for a manufacturer to ''split'' an engine shared among many vehicle model/configurations into myriad versions each optimized to a single vehicle model/configuration.

National Environmental Policy Act: NEPA requires NHTSA to consider the environmental impacts of its actions in its decision-making processes, including for CAFE standards. The Final EIS accompanying this final rule documents changes in emission inventories as estimated using the CAFE Model, but also documents corresponding estimates—based on the application of other models documented in the Final EIS—of impacts on the global climate, on air quality, and on human health.

Other Aspects of Compliance: Beyond these statutory requirements applicable to DOT, EPA, or both are a number of specific technical characteristics of CAFE, HDPUV, and/or GHG regulations that are also relevant to the construction of this analysis, like the ''off-cycle'' technology fuel economy/emissions improvements that apply for both CAFE and GHG compliance. Although too little information is available to account for these provisions explicitly in the same way that NHTSA has accounted for other technologies, the CAFE Model includes and makes use of inputs reflecting NHTSA's expectations regarding the extent to which manufacturers may earn such credits, along with estimates of corresponding costs. Similarly, the CAFE Model includes and makes use of inputs regarding credits EPA has elected to allow manufacturers to earn toward GHG levels (not CAFE or HDPUV) based on the use of air conditioner refrigerants with lower global warming potential, or on the application of technologies to reduce refrigerant leakage. In addition, the CAFE Model accounts for EPA ''multipliers'' for certain AFVs, based on current regulatory provisions or on alternative approaches. Although these are examples of regulatory provisions that arise from the exercise of discretion rather than specific statutory mandate, they can materially impact outcomes.

3. What updated assumptions does the current model reflect as compared to the 2022 final rule and the 2023 NPRM?

Besides the updates to the CAFE Model described above, any analysis of regulatory actions that will be implemented several years in the future, and whose benefits and costs accrue over decades, requires a large number of assumptions. Over such time horizons, many, if not most, of the relevant assumptions in such an analysis are inevitably uncertain. Each successive CAFE and HDPUV analysis seeks to update assumptions to better reflect the current state of the world and the best current estimates of future conditions.

A number of assumptions have been updated since the 2022 final rule and the 2023 NPRM. As discussed below, NHTSA continues to use a MY 2022 reference fleet for passenger cars and light trucks and continues to use an updated HDPUV analysis fleet (the last HDPUV analysis fleet was built in 2016). NHTSA has also updated estimates of manufacturers' compliance credit ''holdings,'' updated fuel price projections to reflect the U.S. EIA's 2023 Annual Energy Outlook (AEO), updated projections of GDP and related macroeconomic measures, and updated projections of future highway travel. While NHTSA would have made these updates as a matter of course, we note that the ongoing global economic recovery and the ongoing war in Ukraine have impacted major analytical inputs such as fuel prices, GDP, vehicle production and sales, and highway travel. Many inputs remain uncertain, and NHTSA has conducted sensitivity analyses around many inputs to attempt to capture some of that uncertainty. These and other updated analytical inputs are discussed in detail in the TSD and FRIA.

Additionally, as discussed in the TSD,[149] NHTSA calculates the climate benefits resulting from anticipated reductions in emissions of each of three GHGs, CO_2, CH_4, and N_2O, using estimates of the social costs of greenhouse gases (SC–GHG) values reported in a recent report from EPA (henceforward referred to as the ''2023 EPA SC–GHG Report'').[150] In the 2022 final rule and the 2023 NPRM, NHTSA used SC–GHG values recommended by the federal Interagency Working Group (IWG) on the SC–GHG for interim use until updated estimates are available. In this final rule, NHTSA has elected to use the updated values in the 2023 EPA SC–GHG Report to reflect the most recent scientific evidence on the cost of climate damages resulting from emission of GHGs. Those estimates of costs per ton of emissions (or benefits per ton of emissions reductions) are greater than those applied in the analysis supporting the 2022 final rule or the 2023 NPRM. Even still, the estimates NHTSA is now using are not able to fully quantify and monetize a number of important categories of climate damages; because of those omitted damages and other methodological limits, DOT believes its values for SC–GHG are conservative underestimates.

B. What is NHTSA analyzing?

NHTSA is analyzing the effects of different potential CAFE and HDPUV standards on industry, consumers, society, and the world at large. These different potential standards are identified as regulatory alternatives, and amongst the regulatory alternatives, NHTSA identifies which ones the agency is selecting. As in the past several CAFE rulemakings and in the Phase 2 HDPUV rulemaking, NHTSA is establishing attribute-based CAFE and HDPUV standards defined by either a mathematical function of vehicle footprint (which has an observable correlation with fuel economy) or a towing-and-hauling-based WF, respectively.[151] EPCA, as amended by EISA, expressly requires that CAFE standards for passenger cars and light trucks be based on one or more vehicle attributes related to fuel economy, and be expressed in the form of a mathematical function.[152] The statute gives NHTSA discretion as to how to structure standards for HDPUVs, and NHTSA continues to believe that attribute-based standards expressed as a mathematical function remain appropriate for those vehicles as well,

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[149] See TSD Chapter 6.2.1

[150] EPA 2023. EPA Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances. National Center for Environmental Economics, Office of Policy, Climate Change Division, Office of Air and Radiation. Washington, DC. Available at: *https://www.epa.gov/environmental-economics/scghg.* (Accessed: Mar. 22, 2024) (hereinafter, ''2023 EPA SC–GHG Report'').

[151] Vehicle footprint is the vehicle's wheelbase times average track width (or more simply, the length and width beween the vehicle's four wheels). The HDPUV FE towing-and-hauling-based work factor (WF) metric is based on a vehicle's payload and towing capabilities, with an added adjustment for 4-wheel drive vehicles.

[152] 49 U.S.C. 32902(a)(3)(A).

given their similarity in many ways to light trucks. Thus, the standards (and the regulatory alternatives) for passenger cars and light trucks take the form of fuel economy targets expressed as functions of vehicle footprint (the product of vehicle wheelbase and average track width) that are separate for passenger cars and light trucks, and the standards and alternatives for HDPUVs take the form of fuel consumption targets expressed as functions of vehicle WF (which is in turn a function of towing and hauling capabilities).

For passenger cars and light trucks, under the footprint-based standards, the function defines a fuel economy performance target for each unique footprint combination within a car or truck model type. Using the functions, each manufacturer thus will have a CAFE average standard for each year that is almost certainly unique to each of its fleets,[153] based upon the footprint and production volumes of the vehicle models produced by that manufacturer. A manufacturer will have separate footprint-based standards for cars and for trucks, consistent with 49 U.S.C. 32902(b)'s direction that NHTSA must set separate standards for cars and for trucks. The functions are mostly sloped, so that generally, larger vehicles (*i.e.,* vehicles with larger footprints) will be subject to lower mpg targets than smaller vehicles. This is because smaller vehicles are generally more capable of achieving higher levels of fuel economy, mostly because they tend not to have to work as hard (and therefore to require as much energy) to perform their driving task. Although a manufacturer's fleet average standard could be estimated throughout the MY based on the projected production volume of its vehicle fleet (and are estimated as part of EPA's certification process), the standards with which the manufacturer must comply are determined by its final model year (FMY) production figures. A manufacturer's calculation of its fleet average standards, as well as its fleets' average performance at the end of the MY, will thus be based on the production-weighted average target and performance of each model in its fleet.[154]

For passenger cars, consistent with prior rulemakings, NHTSA is defining fuel economy targets as shown in Equation III–1.

$$\boldsymbol{TARGET_{FE}} = \frac{\mathbf{1}}{\boldsymbol{MIN\ [MAX\ \left(c\ \times FOOTPRINT + d, \frac{1}{a}\right), \frac{1}{b}]}}$$

Equation III-1: Passenger Car Fuel Economy Footprint Target Curve

Where:

$TARGET_{FE}$ is the fuel economy target (in mpg) applicable to a specific vehicle model type with a unique footprint combination,

a is a minimum fuel economy target (in mpg),

b is a maximum fuel economy target (in mpg),

c is the slope (in gallons per mile (or gpm) per square foot) of a line relating fuel consumption (the inverse of fuel economy) to footprint, and

d is an intercept (in gpm) of the same line.

Here, *MIN* and *MAX* are functions that take the minimum and maximum values, respectively, of the set of included values. For example, *MIN*[40, 35] = 35 and *MAX*(40, 25) = 40, such that *MIN*[*MAX*(40, 25), 35] = 35.

For the Preferred Alternative, this equation is represented graphically as the curves in Figure III–1.

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[153] EPCA/EISA requires NHTSA and EPA to separate passenger cars into domestic and import passenger car fleets for CAFE compliance purposes (49 U.S.C. 32904(b)), whereas EPA combines all passenger cars into one fleet for GHG compliance purposes.

[154] As discussed in prior rulemakings, a manufacturer may have some vehicle models that exceed their target and some that are below their target. Compliance with a fleet average standard is determined by comparing the fleet average standard (based on the production-weighted average of the target levels for each model) with fleet average performance (based on the production-weighted average of the performance of each model). This is inherent in the statutory structure of CAFE, which requires NHTSA to set *corporate average* standards.

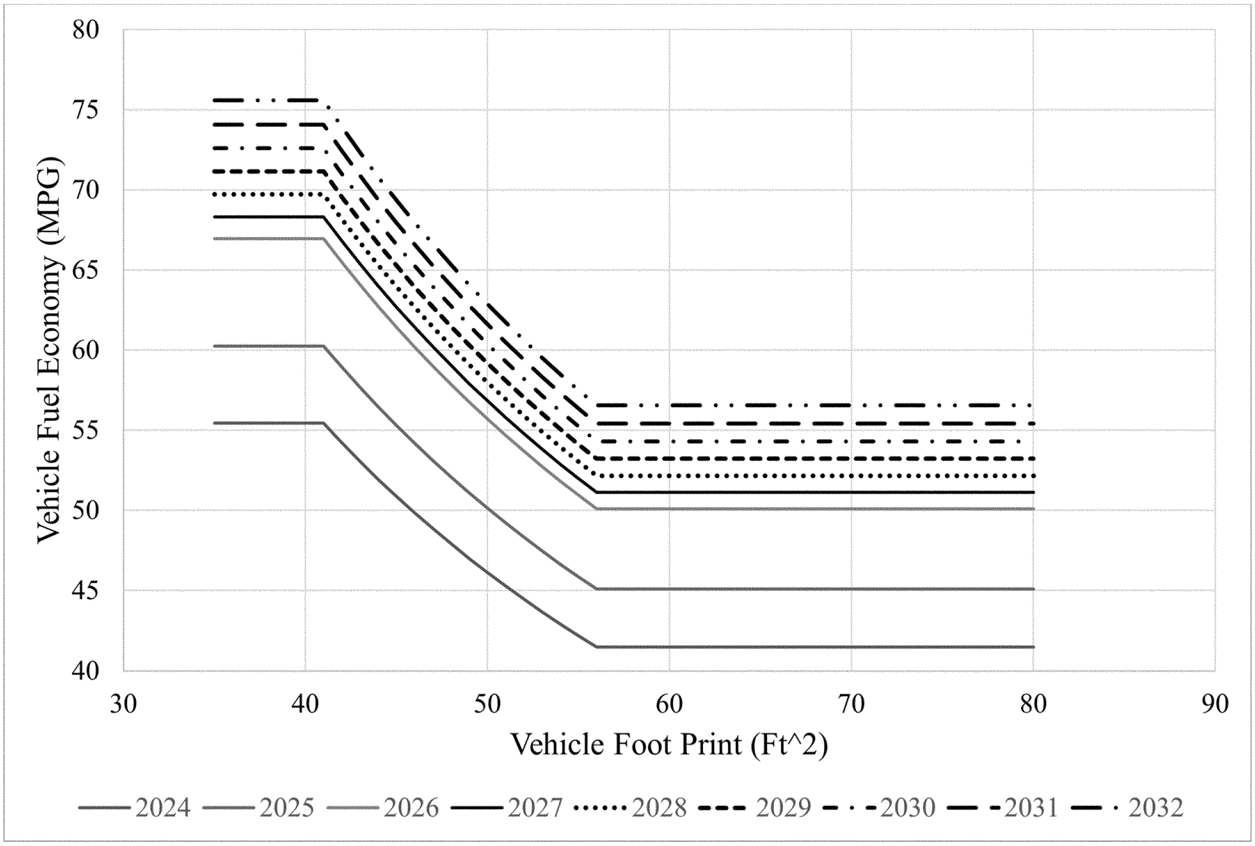

Figure III-1: Preferred Alternative, Fuel Economy Target Curves, Passenger Cars

For light trucks, also consistent with prior rulemakings, NHTSA is defining fuel economy targets as shown in Equation III–2.

$$TARGET_{FE} = \frac{1}{MIN\ [MAX\ \left(c\ \times FOOTPRINT + d, \frac{1}{a}\right), \frac{1}{b}]}, \frac{1}{MIN\ [MAX\left(g\ \times FOOTPRINT + h, \frac{1}{e}\right), \frac{1}{f}]}$$

Equation III-2: Light Truck Fuel Economy Footprint Target Curve

Where:

TARGET$_{FE}$ is the fuel economy target (in mpg) applicable to a specific vehicle model type with a unique footprint combination,

a, b, c, and *d* are as for passenger cars, but taking values specific to light trucks,

e is a second minimum fuel economy target (in mpg),

f is a second maximum fuel economy target (in mpg),

g is the slope (in gpm per square foot) of a second line relating fuel consumption (the inverse of fuel economy) to footprint, and

h is an intercept (in gpm) of the same second line.

For the Preferred Alternative, this equation is represented graphically as the curves in Figure III–2.

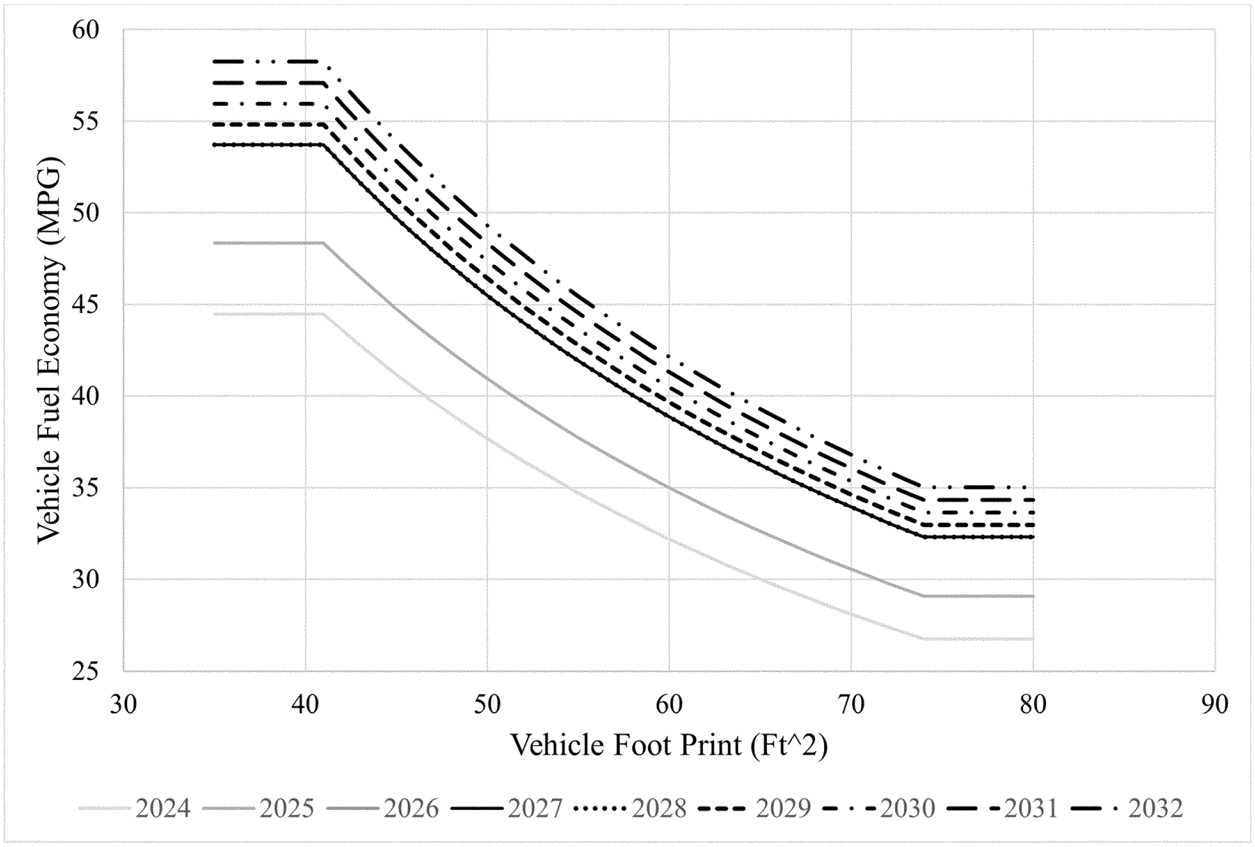

Figure III-2: Preferred Alternative, Fuel Economy Target Curves, Light Trucks

Although the general model of the target function equation is the same for passenger cars and light trucks, and the same for each MY, the parameters of the function equation differ for cars and trucks. The actual parameters for both the Preferred Alternative and the other regulatory alternatives are presented in Section IV.

The required CAFE level applicable to a passenger car (either domestic or import) or light truck fleet in a given MY is determined by calculating the production-weighted harmonic average of fuel economy targets applicable to specific vehicle model configurations in the fleet, as shown in Equation III–3.

$$CAFE_{required} = \frac{\sum_i PRODUCTION_i}{\sum_i \frac{PRODUCTION_i}{TARGET_{FE,i}}}$$

Equation III-3: Calculation for Required CAFE Level

Where:

$CAFE_{required}$ is the CAFE level the fleet is required to achieve,

i refers to specific vehicle model/configurations in the fleet,

$PRODUCTION_i$ is the number of model configuration i produced for sale in the U.S., and

$TARGET_{FE,\,i}$ is the fuel economy target (as defined above) for model configuration i.

For HDPUVs, NHTSA has previously set attribute-based standards, but used a work-based metric as the attribute rather than footprint. Work-based measurements such as payload and towing capability are key among the parameters that characterize differences in the design of these vehicles, as well as differences in how the vehicles will be used. Since NHTSA has been regulating HDPUVs, these standards have been based on a work factor (WF) attribute that combines the vehicle's payload and towing capabilities, with an added adjustment for 4-wheel drive vehicles. Again, while NHTSA is not required by statute to set HDPUV standards that are attribute-based and that are described by a mathematical function, NHTSA continues to believe that doing so is reasonable and appropriate for this segment of vehicles, consistent with prior HDPUV standard-setting rulemakings. NHTSA is continuing the use of the work-based attribute and gradually increasing stringency (which for HDPUVs means that standards appear to *decline,* as compared to passenger car and light truck standards where increasing stringency means that standards appear to *increase.* This is because HDPUV standards are based on fuel *consumption,* which is the inverse of fuel *economy,*[155] the metric that NHTSA

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[155] For additional information, see the National Academies of Sciences, Engineering, and Medicine. 2011. Assessment of Fuel Economy Technologies for Light-Duty Vehicles. *The National Academies Press.* Washington, DC. Available at: *https://*

Continued

is statutorily required to use when setting standards for light-duty vehicle (LDV) fuel use). NHTSA defines HDPUV fuel efficiency targets as shown in Equation III–4.

$$\boldsymbol{Subconfiguration\ Target\ Standard\ (gallons\ per\ 100\ miles) = [c\ \times (WF)] + d}$$

Equation III-4: HDPUV Fuel Efficiency Work Factor Target Curve

Where:

c is the slope (in gal/100-miles/WF)

d is the y-intercept (in gal/100-miles)

WF = Work Factor = [0.75 × (*Payload Capacity* + *Xwd*)] + [0.25 × *Towing Capacity*]

Where:

Xwd = 4wd adjustment = 500 lbs. if the vehicle group is equipped with 4WD and all-wheel drive, otherwise equals 0 lbs. for 2wd

Payload Capacity = GVWR (lbs.) − Curb Weight (lbs.) (for each vehicle group)

Towing Capacity = GCWR[156] (lbs.) − GVWR (lbs.) (for each vehicle group)

For the Preferred Alternative, this equation is represented graphically as the curves in Figure III–3 and Figure III–4.

Figure III-3: Preferred Alternative, Fuel Efficiency Target Curves, HDPUVs – Compression Ignition (Diesel), BEVs and FCEVs)

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nap.nationalacademies.org/catalog/12924/assessment-of-fuel-economy-technologies-for-light-duty-vehicles. (Accessed: Feb. 23, 2024). Fuel economy is a measure of how far a vehicle will travel with a gallon (or unit) of fuel and is expressed in mpg. Fuel consumption is the inverse of fuel economy. It is the amount of fuel consumed in driving a given distance. Fuel consumption is a fundamental engineering measure that is directly related to fuel consumed per 100 miles and is useful because it can be employed as a direct measure of volumetric fuel savings.

[156] Gross Combined Weight Rating.

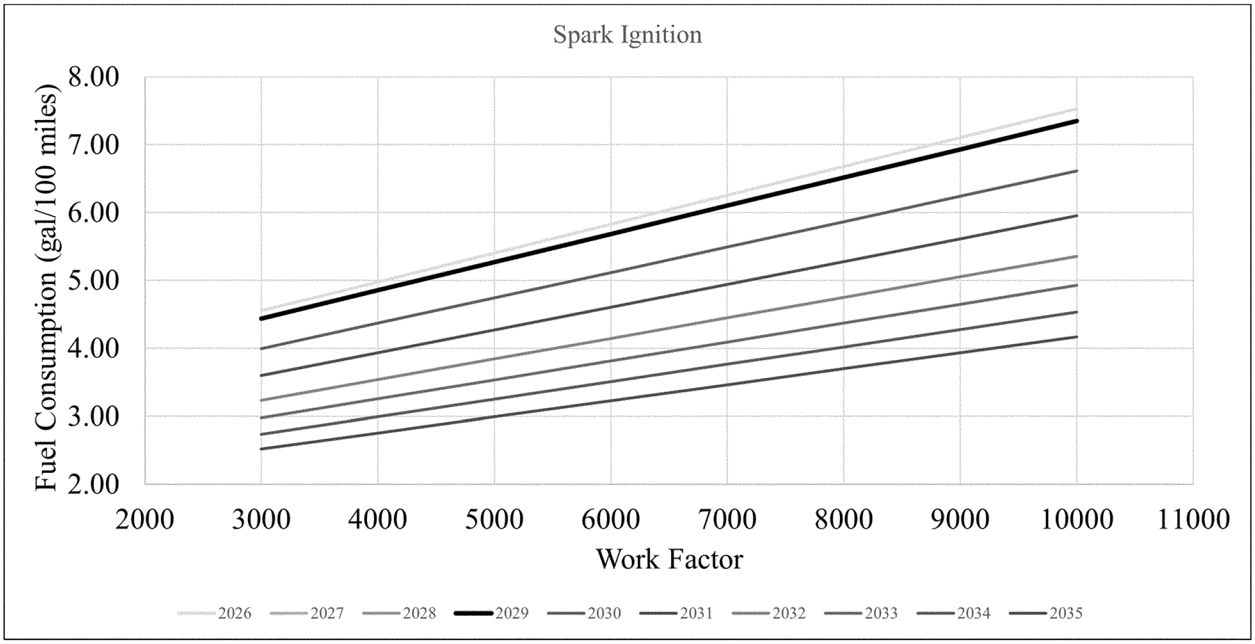

Figure III-4: Preferred Alternative, Fuel Efficiency Target Curves, HDPUVs – Spark Ignition (Gasoline), PHEVs, SHEVs, and CNG

Similar to the standards for passenger cars and light trucks, NHTSA (and EPA) have historically set HDPUV standards such that each manufacturer's fleet average standard is based on production volume-weighting of target standards for all vehicles, which are based on each vehicle's WF as explained above. Thus, for HDPUVs, the required fuel efficiency level applicable in a given MY is determined by calculating the production-weighted harmonic average of subconfiguration targets applicable to specific vehicle model configurations in the fleet, as shown in Equation III–5.

$$Fleet\ Average\ Standard = \frac{\sum[Subconfiguration\ Target\ Standard_i \times Volume_i]}{\sum[Volume_i]}$$

Equation III-5: HDPUV Fuel Efficiency Work Factor Target Curve

Where:

Subconfiguration Target Standard$_i$ = fuel consumption standard for each group of vehicles with the same payload, towing capacity, and drive configuration (gallons per 100 miles), and

Volume$_i$ = production volume of each unique subconfiguration of a model type based upon payload, towing capacity, and drive configuration.

Chapter 1 of the TSD contains a detailed description of the use of attribute-based standards, generally, for passenger cars, light trucks, and HDPUVs, and explains the specific decision, in past rules and for the current final rule, to continue to use vehicle footprint as the attribute over which to vary passenger car and light truck stringency, and WF as the attribute over which to vary HDPUV stringency. That chapter also discusses the policy and approach in selecting the specific mathematical functions.[157]

Commenters expressed several concerns regarding the implementation of the fuel economy footprint target curves used for passenger cars and light trucks in this rule. Most concerns fell into one of four categories: the use of alternate or additional factors in generating the curves, the shape of the attribute curve, consideration of how footprint changes may be expressed or used by manufacturers, and considerations of changes made by the EPA in its own rulemaking.

Regarding the use of alternate or additional factors in generating the curves, Rivian commented that NHTSA should reconsider the National Academy of Sciences (NAS) recommendation for multi-attribute standards for CAFE and requested that the agency ''more fully describe why'' the alternative approach to including electrification as another attribute described in the MYs 2024–2026 proposal ''would be inconsistent with its current legal authority.''[158]

In the 2021 NAS Report, the committee recommended that if Congress did not act to remove the prohibition at 49 U.S.C. 32902(h) on considering the fuel economy of dedicated AFVs (like BEVs) in determining maximum feasible CAFE standards, then the Secretary (by delegation, NHTSA) should consider accounting for the fuel economy

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[157] See TSD Chapter 1.2.

[158] Rivian, Docket No. NHTSA–2023–0022–59765, at 3–4.

benefits of ZEVs by ''setting the standard as a function of a second attribute in addition to footprint—for example, the expected market share of ZEVs in the total U.S. fleet of new light-duty vehicles—such that the standards increase as the share of ZEVs in the total U.S. fleet increases.'' [159] NHTSA remains concerned that adding electrification, specifically, as part of a multi-attribute approach to standards may be inconsistent with our current legal authority. The 49 U.S.C. 32902(h) prohibition against considering the fuel economy of electric vehicles applies to the determination of maximum feasible standards. The attribute-based target curves *are themselves* the standards. NHTSA therefore does not see how the fuel economy of electric vehicles could be incorporated as an attribute forming the basis of the standards. Moreover, NHTSA further explored and received comments on this issue in the final rule setting standards for MYs 2024–2026.[160] While NHTSA considered this recommendation carefully as part of that rulemaking, NHTSA ultimately agreed with many commenters that including electrification as an attribute on which to base fuel economy standards for that rulemaking could introduce lead time concerns and uncertainty for industry needing to adjust their compliance strategies.

The Center for Environmental Accountability (CEA) also commented on considering the use of acceleration as an additional attribute in the attribute based standard function.[161] The CEA was concerned with capturing the potential trade off manufacturers may make between improved vehicle performance or improved fuel economy. NHTSA provides discussion and reasoning for the agency's approach to performance trade-offs in Section III.C.3 and believes the approach of maintaining performance neutrality is a reasonable method for accounting for the variety of possible manufacturer decisions. Furthermore, to date, every time NHTSA has considered options for which attribute(s) to select, the agency has concluded that a properly designed footprint-based approach provides the best means of achieving the basic policy goals (*i.e.,* by increasing the likelihood of improved fuel economy across the entire fleet of vehicles) involved in applying an attribute-based standard.[162]

Other commenters expressed concern about the possible influence of the shape, slope or cutpoints of the footprint curve on real-world vehicle footprint size. The Institute for Policy Integrity (IPI) and the Natural Resources Defense Council (NRDC) both argued that NHTSA should flatten the footprint curves to discourage upsizing, because larger vehicles consume more energy.[163] NRDC also stated that ''NHTSA should further reduce the footprint of the cutpoint for light trucks based on pickup certification.'' [164] Other commenters expressed similar concerns.[165]

NHTSA appreciates these comments but based on the detailed discussion presented in Chapter 1.2.3.1 of the TSD, NHTSA is retaining the same curve shapes for passenger car and light truck standards in this final rule that NHTSA has used over the past several rulemakings—that is, at this time NHTSA is not changing the shape of the existing footprint curves. Based on the analysis of data presented by the EPA Trends Report discussed in the TSD,[166] vehicle footprint size, by vehicle category, has in fact changed very little over the last decade. By sales-weighted average, the data examined showed that sedans and wagons increased their footprints the most, about 3.4% or a 2 ft^2 increase, over 10 years. For context, a 1.5 ft^2 increase in overall footprint increase would equate to about a 2 inch increase in the track width of a MY 2022 Toyota Corolla.[167] NHTSA's assessment in the TSD shows that over the 10 years it took for manufacturers to increase sedan footprint by 3.4% on average, the fuel economy consequence was approximately a 3% reduction in the MY 2022 fuel economy target for a Toyota Corolla, compared to if it had retained its MY 2012 footprint size. Spread over each of those 10 years, the footprint increases for the example Corolla resulted in fuel economy targets that were lowered by approximately 0.3% per year. While NHTSA agrees that this number is greater than zero, for context, the fuel economy standard improvement from MY 2023 to MY 2024 will require approximately an 8% increase in fuel economy—in other words, the increases in CAFE stringency are decidedly outpacing manufacturers' current ability, or plans, to upsize individual vehicle footprints to obtain lower targets.

NHTSA notes, however, that while increases in footprint size by vehicle category are small, there is a separate phenomenon of aggregate footprint increase for the entire fleet, which NHTSA found to be about 5.4% over the same time period. This is due not to changes in individual vehicle size or vehicle-class-level size, but to changes in fleet share. The fleet share of generally-smaller-footprint sedans and wagons decreased by nearly 28.4% over 10 years, while the fleet share of generally-larger-footprint trucks, SUVs, and pickups increased by 29.5%. Simply put, manufacturers are selling more larger trucks and fewer smaller cars than they were 10 years ago—which is different from individual vehicle models (or vehicle classes) themselves increasing in size, as one might expect if the shape of the footprint curves or the use of footprint as an attribute were incentivizing upsizing. This evidence leads us to conclude that the use of footprint as an attribute and the current slopes and cutoff points for the existing curves for passenger car and light truck CAFE standards do not lead to manufacturers significantly altering the size of their vehicles, within vehicle classes.

In contrast, Mitsubishi argued that the current shape of the curves, and particularly the passenger car curve, discouraged manufacture of smaller footprint vehicles. As Mitsubishi stated,

> Mitsubishi holds a unique position in the industry as the manufacturer with the smallest fleet-average vehicle footprint. As such, Mitsubishi also has the strictest GHG and CAFE standard among vehicle manufacturers. Despite having one of the highest fleet-average fuel economy ratings and the lowest fleet GHG emissions of any mass-market vehicle manufacturer, Mitsubishi has accrued CAFE and GHG deficits in recent years, while other manufacturers with lower CAFE and higher GHG fleet emissions have accrued credits. While we understand the math that delivers this result, we question whether this outcome

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[159] National Academies of Sciences, Engineering, and Medicine. 2021. Assessment of Technologies for Improving Fuel Economy of Light-Duty Vehicles—2025–2035. *The National Academies Press.* Washington, DC at 5. Available at: *https://www.nationalacademies.org/our-work/assessment-of-technologies-for-improving-fuel-economy-of-light-duty-vehicles-phase-3.* (Accessed Feb. 7, 2024) (hereinafter, ''2021 NAS Report''). Summary Recommendation 5, at 368.

[160] 87 FR 25753.

[161] CEA, Docket No. NHTSA–2023–0022–61918, at 22.

[162] See TSD Chapter 1.2.3.1; NHTSA. Mar. 2022. TSD Final Rulemaking for Model Years 2024–2026 Light-Duty Corporate Average Fuel Economy Standards. Chapter 1.2.3; 85 FR 24249–24257 (April 30, 2020).

[163] IPI, Docket No. NHTSA–2023–0022–60485, at 1; Joint NGOs, Docket No. NHTSA–2023–0022–61944–A2, at 30–34.

[164] Joint NGOs, Docket No. NHTSA–2023–0022–60485, at 34.

[165] SELC, Docket No NHTSA–2023–0022–60224, at 7; Climate Hawks Civic Action, Docket No NHTSA–2023–0022–61094, at 1042; MEMA, Docket No. NHTSA–2023–0022–59204, at 8–9; ACEEE, Docket No NHTSA–2023–0022–60684, at 3; CBD *et al.,* Docket No. NHTSA–2023–0022–61944–A2, at 41.

[166] 2023 EPA Technology Trends Report.

[167] The MY 2022 Corolla has a wheelbase of about 106 inches, adding 2 inches to the track width would add approximately 212 square inches or 1.47 square feet to the footprint of the vehicle. See the Market Data Input File for data on the 2022 Corolla wheelbase.

is what the program set out to achieve. Mitsubishi supports the reevaluation of the shape and slope of the footprint curves to ensure fleetwide fuel economy increases and GHG reductions are done in a neutral manner.[168]

NHTSA is aware of Mitsubishi's unique position in the industry as a manufacturer of smaller, highly fuel-efficient, affordably-priced vehicles and is sympathetic to these comments. Unfortunately, the standard is designed for the overall industry rather than for individual manufacturers. The format of NHTSA's standards, with target goals based on footprint, instead allows each manufacturer's compliance obligation to vary with their sales mix. This can cause difficulty for some manufacturers if their vehicles' average fuel economy does not meet the required average of their footprint targets. Mitsubishi is correct that the current curve shapes do not incentivize manufacturers to build smaller cars—but neither does NHTSA find, as discussed above, that they particularly incentivize manufacturers to build larger cars, perhaps contrary to expectation. Unfortunately, the overall structure of the target curves places Mitsubishi—like all other manufacturers—in a position where it must balance its need to increase the fuel economy of its fleet with marketing increasing vehicle costs to its consumer base.

IPI suggested that NHTSA add the use of increased footprint size as a potential compliance strategy used during the simulation of manufacturer behavior, stating that ''This upsizing could be modeled either directly as a vehicle-level change (*i.e.,* a technology change) or approximated by applying a specific level of sales-weighted average increase to the vehicle class level. In the former case, NHTSA could include footprint technology options, such as increased footprint size by 0%, 5%, 7.5%, 10%, 15%, and 20%, much like NHTSA treats mass-reduction technologies.'' [169]

NHTSA disagrees that additional modeling approaches are required to capture the behavior of the manufacturers that appears to lead to increasing fleet footprint. The analysis of the EPA's Trends Data, discussed above and provided in detail in TSD Chapter 1.2.3.1, indicates that over the last 10 years vehicle footprint size has seen only small changes within vehicle classes. Sedans and wagons showed the greatest sales-weighted average increase between MY 2012 and MY 2022 at a 3.4% increase, minivans saw a 2.1% increase, car SUVs (or crossovers) saw a 1.6% increase, truck SUVs saw a 0.9% increase, and pickups saw the smallest increase at 0.5%. The increase in sales-weighted average footprint size for the aggregate fleet instead appears driven by a change in fleet shares between passenger cars and light trucks—a behavior that is captured by the CAFE model and is discussed in TSD Chapter 4.2.1.3, Modeling Changes in Fleet Mix.

Several commenters expressed concern that NHTSA had not followed EPA's proposed approach to reconfiguring their attribute-based CO_2 standard functions. Mitsubishi stated, ''Unlike the EPA, NHTSA did not propose any changes to the slope or cut-points for the passenger car or light truck curves.'' [170] The Motor & Equipment Manufacturer's Association (MEMA) offered similar comments, stating, ''NHTSA should follow EPA's lead in flattening the curves to further improve the fuel efficiency of the overall fleet and limit upsizing.'' [171] Other commenters also expressed concern about the departure in target curve shape between EPA's proposed standards and NHTSA proposed standards, arguing that NHTSA should have considered the same factors EPA used in their determinations.[172]

NHTSA has explained our position on changing curve shape based on addressing concerns about upsizing above. That said, NHTSA is aware that EPA recently issued a final rule changing the shapes of its CO_2 standards curves for passenger cars and light-duty trucks, as compared to its prior set of standards. EPA explained that it chose to make the slopes of both curves, especially the car curves, flatter than those of prior rulemakings, stating that:

> When emissions reducing technology is applied, such as advanced ICE, or HEV or PHEV or BEV electrification technologies, the relationship between increased footprint and tailpipe emissions is reduced. From a physics perspective, a positive footprint slope for ICE vehicles makes sense because as a vehicle's size increases, its mass, road loads, and required power (and corresponding vehicle-based CO_2 emissions) will increase accordingly [and its fuel economy will correspondingly decrease accordingly]. Moreover, as the emissions control technology becomes increasingly more effective, the relationship between tailpipe emissions and footprint decreases proportionally; in the limiting case of vehicles with 0 g/mile tailpipe emissions such as BEVs, there is no relationship at all between tailpipe emissions and footprint.[173]

Since the Supreme Court's decision in *Massachusetts* v. *EPA*, NHTSA and EPA have both employed equivalent footprint-based CAFE and CO_2 target curves for PCs and LTs. In this final rule, NHTSA cannot reasonably promulgate target curves that are flatter, like EPA's new curves based on EPA's rationale, for two main reasons. First, EPA altered their curves based on considering the effects of emission reduction technologies such as PHEVs and BEVs as viable solutions to meet their standards. Given that the target curves *are* the CAFE standards, and given that 49 U.S.C. 32902(h) prohibits consideration of BEVs or even the electric only operation of PHEVs in determining maximum feasible CAFE standards, NHTSA does not believe that the law permits us to base target curve shapes in CAFE-standard-driven increases on the presence (*i.e.,* the fuel economy) of BEVs or the use of the electric operation of PHEVs in the vehicle fleets. Second, even if NHTSA could consider BEVs and full use of PHEV technology in developing target curve shapes, NHTSA would not consider them the same way as EPA does. BEV compliance values in the CAFE program are determined, per statute, using DOE's Petroleum Equivalency Factor. Moreover, the calculated equivalent fuel economies still vary with vehicle footprint and, in general, larger vehicles have lower calculated equivalent fuel economies. They are not the fuel-economy-equivalent of 0 g/mi, which would be infinite fuel economy. NHTSA, therefore, cannot adopt EPA's rationale that curve slopes should become flatter in response to increasing numbers of BEVs because our statutory requirements for how BEV fuel economy is calculated necessarily differ from how EPA chooses to calculate CO_2 emissions for BEVs. NHTSA understands that this divergence in curve shape creates inconsistency between the programs, but NHTSA does not agree that the agency currently has authority to harmonize with EPA's new approach to curve shape.

Regarding the fuel consumption work factor target curves proposed for HDPUVs, stakeholders expressed two types of comments. First, a group of commenters expressed support for the continued use of the work factor attribute, and second, some stakeholders

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[168] Mitsubishi, Docket No. NHTSA–2023–0022–61637 at 7.

[169] IPI, Docket No. NHTSA–2023–0022–60485, at 16–18.

[170] Mitsubishi, Docket No. NHTSA–2023–0022–61637, at 7.

[171] MEMA, Docket No. NHTSA–2023–0022–59204, at 8.

[172] CBD et al., Docket No. NHTSA–2023–0022–61944, at 41; IPI, Docket No. NHTSA–2023–0022–60485, at 16–18; ACEEE, Docket No. NHTSA–2023–0022–60684, at 3.

[173] 2024 EPA Final Rule, section II.C.2.ii, 89 FR 27842.

expressed concern over NHTSA maintaining separate diesel and gasoline compliance curves.

On the use of the work factor attribute, the Alliance stated, ''We agree with NHTSA's conclusion that work factor is a reasonable and appropriate attribute for setting fuel consumption standards. Work factor effectively captures the intent of these vehicles, which is to perform work, and has a strong correlation to fuel consumption.'' [174] These sentiments were echoed by other commenters.[175] NHTSA agrees with the stakeholders, and after considering these comments, the agency has once again concluded that the work factor approach established in the 2011 ''Phase 1'' rulemaking and continued in the 2016 ''Phase 2'' rulemaking is reasonable and appropriate.

On the continued use of separate diesel and gasoline curves for the HDPUV standards, the American Council for an Energy-Efficient Economy (ACEEE) commented, ''In further alignment with EPA, NHTSA should eliminate the different standards for diesel and gasoline (*i.e.,* compression-ignition and spark-ignition) HDPUVs.'' [176] ACEEE argued further that ''Given NHTSA's acknowledgement of the emergence of van electrification and its history of alignment with EPA for HDPUVs, raising the stringency of the gasoline standards to match that of the diesel standards should be feasible.'' [177]

ACEEE requested that NHTSA align with EPA by developing a single standard curve for both SI and CI HDPUVs for MYs 2027 through 2032. As mentioned in the NPRM, NHTSA is statutorily required to provide at least four full MYs of lead time and three full MYs of regulatory stability for its HDPUV fuel consumption standards. As such, we are unable to align with EPA's change to its standard due to an insufficient amount of lead time. However, we believe the regulatory stability of the current HDPUV fuel consumption standards provide enough stability for the industry to continue to develop technologies needed to meet our standards. In addition, we believe retaining separate CI and SI curves will better balance NHTSA's statutory factors.[178]

C. What inputs does the compliance analysis require?

The first step in our analysis of the effects of different levels of fuel economy standards is the compliance simulation. When we say, ''compliance simulation'' throughout this rulemaking, we mean the CAFE Model's simulation of how vehicle manufacturers could comply with different levels of CAFE standards by adding fuel economy-improving technology to an existing fleet of vehicles.[179] At the most basic level, a model is a set of equations, algorithms,[180] or other calculations that are used to make predictions about a complex system, such as the environmental impact of a particular industry or activity. A model may consider various inputs, such as emissions data, technology costs, or other relevant factors, and use those inputs to generate output predictions.

One important note about models is that a model is only as good as the data and assumptions that go into it. We attempt to ensure that the technology inputs and assumptions that go into the CAFE Model to project the effects of different levels of CAFE standards are based on sound science and reliable data, and that our reasons for using those inputs and assumptions are transparent and understandable to stakeholders. This section and the following section discuss at a high level how we generate the technology inputs and assumptions that the CAFE Model uses for the compliance simulation.[181] The TSD, CAFE Model Documentation, CAFE Analysis Autonomie Model Documentation,[182] and other technical reports supporting this final rule discuss our technology inputs and assumptions in more detail.

We incorporate technology inputs and assumptions either directly in the CAFE Model or in the CAFE Model's various input files. The heart of the CAFE Model's decisions about how to apply technologies to manufacturer's vehicles to project how the manufacturer could meet CAFE standards is the compliance simulation algorithm. The compliance simulation algorithm is several equations that direct the model to apply fuel economy-improving technologies to vehicles in a way that estimates how manufacturers might apply those technologies to their vehicles in the real world. The compliance simulation algorithm projects a cost-effective pathway for manufacturers to comply with different levels of CAFE standards, considering the technology present on manufacturer's vehicles now, and what technology could be applied to their vehicles in the future. Embedded directly in the CAFE Model is the universe of technology options that the model can consider and some rules about the order in which it can consider those options and estimates of how effective fuel economy improving-technology is on different types of vehicles, like on a sedan or a pickup truck.

Technology inputs and assumptions are also located in all four of the CAFE Model Input Files. The Market Data Input File is a Microsoft Excel file that characterizes the analysis automotive fleet used as the starting point for CAFE modeling. There is one Excel row describing each vehicle model and model configuration manufactured in the United States in a MY (or years), and input and assumption data that links that vehicle to technology, economic, environmental, and safety effects. Next, the Technologies Input File identifies approximately six dozen technologies we use in the analysis, uses phase-in caps to identify when and how widely each technology can be applied to specific types of vehicles, provides most of the technology costs (only battery costs for electrified vehicles are provided in a separate file), and provides some of the inputs involved in estimating impacts on vehicle fuel consumption and weight. The Scenarios Input File provides the coefficient values defining the standards for each regulatory alternative,[183] and other

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[174] The Alliance, Docket No. NHTSA–2023–0022–60652, at 52–64.

[175] Stellantis, Docket No. NHTSA–2023–0022–61107, at 12; Cummins, Inc., Docket No. NHTSA–2023–0022–60204, at 2; GM, Docket No. NHTSA–2023–0022–60686, at 7.

[176] ACEEE, Docket No. NHTSA–2023–022–60684–A1, at 8.

[177] ACEEE, Docket No. NHTSA–2023–022–60684–A1, at 8.

[178] U.S.C. 32920(k)(2).

[179] When we use the phrase ''the model'' throughout this section, we are referring to the CAFE Model. Any other model will be specifically named.

[180] See Merriam-Webster, ''algorithm.'' Broadly, an algorithm is a step-by-step procedure for solving a problem or accomplishing some end. More specifically, an algorithm is a procedure for solving a mathematical problem (as of finding the greatest common divisor) in a finite number of steps that frequently involves repetition of an operation.

[181] As explained throughout this section, our inputs are a specific number or datapoint used by the model, and our assumptions are based on judgment after careful consideration of available evidence. An assumption can be an underlying reason for the *use* of a specific datapoint, function, or modeling process. For example, an input might be the fuel economy value of the Ford Mustang, whereas the assumption is that the Ford Mustang's fuel economy value reported in Ford's CAFE compliance data should be used in our modeling.

[182] The Argonne report is titled ''Vehicle Simulation Process to Support the Analysis for MY 2027 and Beyond CAFE and MY 2030 and Beyond HDPUV FE Standards;'' however, for ease of use and consistency with the TSD, it is referred to as ''CAFE Analysis Autonomie Documentation.''

[183] The coefficient values are defined in TSD Chapter 1.2.1 for both the CAFE and HDPUV FE standards.

relevant information applicable to modeling each regulatory scenario. This information includes, for example, the estimated value of select tax credits from the IRA, which provide Federal technology incentives for electrified vehicles, and the PEF, which is a value that the Secretary of Energy determines under EPCA that applies to EV fuel economy values.[184] Finally, the Parameters Input File contains mainly economic and environmental data, as well as data about how fuel economy credits and California's Zero Emissions Vehicle program credits are simulated in the model.

We generate these technology inputs and assumptions in several ways, including by and through evaluating data submitted by vehicle manufacturers pursuant to their CAFE reporting obligations; consolidating public data on vehicle models from manufacturer websites, press materials, marketing brochures, and other publicly available information; collaborative research, testing, and modeling with other Federal agencies, like the DOE's Argonne National Laboratory; research, testing, and modeling with independent organizations, like IAV GmbH Ingenieurgesellschaft Auto und Verkehr (IAV), Southwest Research Institute (SwRI), NAS, and FEV North America; determining that work done for prior rules is still relevant and applicable; considering feedback from stakeholders on prior rules, in meetings conducted before the commencement of this rule, and feedback received during the comment period for this final rule; and using our own engineering judgment. When we say ''engineering judgment'' throughout this rulemaking, we are referring to decisions made by a team of engineers and analysts. This judgment is based on their experience working in the automotive industry and other relevant fields, and assessment of all the data sources described above. Most importantly, we use engineering judgment to assess how best to represent vehicle manufacturer's potential responses to different levels of CAFE standards within the boundaries of our modeling tools, as ''a model is meant to simplify reality in order to make it tractable.'' [185] In other words, we use engineering judgment to concentrate potential technology inputs and assumptions from millions of discrete data points from hundreds of sources to three datasets integrated in the CAFE Model and four input files. How the CAFE Model decides to apply technology, *i.e.,* the compliance simulation algorithm, has also been developed using engineering judgment, considering some of the same factors that manufacturers consider when they add technology to vehicles in the real world.

While upon first read this discussion may seem oversimplified, we believe that there is value in all stakeholders being able to understand how the analysis uses different sets of technology inputs and assumptions and how those inputs and assumptions are based on real-world factors. This is so that all stakeholders have the appropriate context to better understand the specific technology inputs and assumptions discussed later and in detail in all of the associated technical documentation.

1. Technology Options and Pathways

We begin the compliance analysis by defining the range of fuel economy-improving technologies that the CAFE Model could add to a manufacturer's vehicles in the United States market.[186] These are technologies that we believe are representative of what vehicle manufacturers currently use on their vehicles, and that vehicle manufacturers could use on their vehicles in the timeframe of the standards (MYs 2027 and beyond for the LD analysis and MYs 2030 and beyond for the HDPUV analysis). The technology options include basic and advanced engines, transmissions, electrification, and road load technologies, which include mass reduction (MR), aerodynamic improvement (AERO), and tire rolling resistance (ROLL) reduction technologies. Note that while EPCA/EISA constrains our ability to consider the possibility that manufacturers would comply with CAFE standards by implementing some electrification technologies when making decisions about the level of CAFE standards that is maximum feasible, there are several reasons why we must accurately model the range of available electrification technologies. These are discussed in more detail in Section III.D and in Section VI.

We require several data elements to add a technology to the range of options that the CAFE Model can consider; those elements include a broadly applicable technology definition, estimates of how effective that technology is at improving a vehicle's fuel economy value on a range of vehicles (*e.g.,* sedan through pickup truck, or HD pickup truck and HD van), and the cost to apply that technology on a range of vehicles. Each technology we select is designed to be representative of a wide range of specific technology applications used in the automotive industry. For example, in MY 2022, eleven vehicle brands under five vehicle manufacturers [187] used what we call a ''downsized turbocharged engine with cylinder deactivation.'' While we might expect brands owned by the same manufacturer to use similar technology on their engines, among those five manufacturers, the engine systems will likely be very different. Some manufacturers may also have been making those engines longer than others, meaning that they have had more time to make the system more efficient while also making it cheaper, as they make gains learning the development improvement and production process. If we chose to model the best performing, cheapest engine and applied that technology across vehicles made by all automotive manufacturers, we would likely be underestimating the cost and underestimating the technology required for the entire automotive industry to achieve higher levels of CAFE standards. The reverse would be true if we selected a system that was less efficient and more expensive. So, in reality, some manufacturers' systems may perform better or worse than our modeled systems, and some may cost more or less than our modeled systems. However, selecting representative technology definitions for our analysis will ensure that, on balance, we capture a reasonable level of costs and benefits that would result from any manufacturer applying the technology.

We have been refining the LD technology options since first developing the CAFE Model in the early 2000s. ''Refining'' means both adding and removing technology options depending on technology availability now and projected future availability in the United States market, while balancing a reasonable amount of modeling and analytical complexity. Since the last analysis we have reduced the number of LD ICE technology options but have refined the options, so they better reflect the diversity of

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[184] *See* 49 U.S.C. 32904(a)(2), 89 FR 22041 (March 29, 2024).

[185] *Chem. Mfrs. Ass'n* v. *E.P.A.,* 28 F.3d 1259, 1264–65 (D.C. Cir. 1994) (citing Milton Friedman. 1953. The Methodology of Positive Economics. *Essays in Positive Economics* 3, at 14–15).

[186] 40 CFR 86.1806–17—Onboard diagnostics; 40 CFR 86.1818–12—Greenhouse gas emission standards for light-duty vehicles, light-duty trucks, and medium-duty passenger vehicles; Commission Directive 2001/116/EC—European Union emission regulations for new LDVs—including passenger cars and light commercial vehicles (LCV).

[187] Ford, General Motors (GM), Honda, Stellantis, and VWA represent the following 11 brands: Acura, Alfa Romeo, Audi, Bentley, Buick, Cadillac, Chevrolet, Ford, GMC, Lamborghini, and Porsche.

engines in the current fleet. Our technology options also reflect an increase in diversity for hybridization and electrification options, though we utilize these options in a manner that is consistent with statutory constraints. In addition to better representing the current fleet, this reflects consistent feedback from vehicle manufacturers who have told us that they will reduce investment in ICEs while increasing investment in hybrid and plug-in BEV options.[188]

Feedback on the past several CAFE rules has also centered thematically on the expected scope of future electrified vehicle technologies and how we should consider future developments in our analysis. We have received feedback that we cannot consider BEV options and even so, our costs underestimate BEV costs when we do consider them in, for example, the reference baseline. We have also received comments that we should consider more electrified vehicle options and our costs overestimate future costs. Consistent with our interpretation of EPCA/EISA, discussed further in Section III.D and VI, we include several LD electrified technologies to appropriately represent the diversity of current and anticipated future technology options while ensuring our analysis remains consistent with statutory limitations. In addition, this ensures that our analysis can appropriately capture manufacturer decision making about their vehicle fleets for reasons other than CAFE standards (*e.g.,* other regulatory programs and manufacturing decisions).

The technology options also include our judgment about which technologies will not be available in the rulemaking timeframe. There are several reasons why we may have concluded that it was reasonable to exclude a technology from the options we consider. As with past analyses, we did not include technologies unlikely to be feasible in the rulemaking timeframe, engines technologies designed for markets other than the United States market that are required to use unique gasoline,[189] or technologies where there were not appropriate data available for the range of vehicles that we model in the analysis (*i.e.* technologies that are still in the research and development phase but are not ready for mass market production). Each technology section below and Chapter 3 of the TSD discusses these decisions in detail.

The HDPUV technology options also represent a diverse range of both internal combustion and electrified powertrain technologies. We last used the CAFE Model for analyzing HDPUV standards in the Phase 2 Medium and Heavy-Duty Greenhouse Gas and Fuel Efficiency joint rules with EPA in 2016.[190] Since issuing that rule, we refined the ICE technology options based on trends on vehicles in the fleet and updated technology cost and effectiveness data. The HDPUV options also reflect more electrification and hybridization options in that real-world fleet. However, the HDPUV technology options are also less diverse than the LD technology options, for several reasons. The HDPUV fleet is significantly smaller than the LD fleet, with five manufacturers building a little over 25 nameplates in one thousand vehicle model configurations,[191] compared with the 20 LDV manufacturers building more than 250 nameplates in the range of over two thousand configurations. Also, by definition, the HDPUV fleet only includes two vehicle types: HD pickup trucks and work vans.[192] These vehicle types have focused applications, which includes transporting people and moving equipment and supplies. As discussed in more detail below, these vehicles are built with specific technology application, reliability, and durability requirements in order to do work.[193] We believe the range of HDPUV technology options appropriately and reasonably represents the smaller range of technology options available currently and for application in future MYs for the United States market.

Note, however, that for both the LD and HDPUV analyses, the CAFE Model does not dictate or predict the technologies manufacturers must use to comply; rather, the CAFE Model outlines a technology pathway that manufacturers could use to meet the standards cost-effectively. While we estimate the costs and benefits for different levels of CAFE standards estimating technology application that manufacturers could use in the rulemaking timeframe, it is entirely possible and reasonable that a vehicle manufacturer will use different technology options to meet our standards than the CAFE Model estimates and may even use technologies that we do not include in our analysis. This is because our standards do not mandate the application of any particular technology. Rather, our standards are performance-based: manufacturers can and do use a range of compliance solutions that include technology application, shifting sales from one vehicle model or trim level to another,[194] and even paying civil penalties. That said, we are confident that the 75 LD technology options and 30 HDPUV technology options included in the analysis (in particular considering that for each technology option, the analysis includes distinct technology cost and effectiveness values for fourteen different types of vehicles, resulting in about a million different technology effectiveness and cost data points) strike a reasonable balance between the diversity of technology used by an entire industry and simplifying reality in order to make modeling tractable.

Chapter 3 of the TSD and Section III.D below describe the technologies that we used for the LD and HDPUV analyses. Each technology has a name that loosely corresponds to its real-world technology equivalent. We abbreviate the name to a short easy signifier for the CAFE Model to read. We organize those technologies into groups based on technology type: basic and advanced engines, transmissions, electrification, and road load technologies, which include MR, aerodynamic improvement, and low rolling resistance tire technologies.

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[188] 87 FR 25781 (May 2, 2022); Docket Submission of Ex Parte Meetings Prior to Publication of the Corporate Average Fuel Economy Standards for Passenger Cars and Light Trucks for Model Years 2027–2032 and Fuel Efficiency Standards for Heavy-Duty Pickup Trucks and Vans for Model Years 2030–2035 Notice of Proposed Rulemaking memorandum, which can be found under References and Supporting Material in the rulemaking Docket No. NHTSA–2023–0022.

[189] In general, most vehicles produced for sale in the United States have been designed to use ''Regular'' gasoline, or 87 octane. See EIA. 2022. Octane in Depth. Last revised: Nov. 17, 2022. Available at: *https://www.eia.gov/energyexplained/gasoline/octane-in-depth.php.* (Accessed: Feb. 23, 2024), for more information.

[190] 81 FR 73478 (Oct. 25, 2016); NHTSA. 2023. CAFE Compliance and Effects Modeling System. Corporate Average Fuel Economy. Available at: *https://www.nhtsa.gov/corporate-average-fuel-economy/cafe-compliance-and-effects-modeling-system.* (Accessed: Feb. 27, 2024).

[191] In this example, a HDPUV ''nameplate'' could be the ''Sprinter 2500'', as in the Mercedes-Benz Sprinter 2500. The vehicle model configurations are each unique variants of the Sprinter 2500 that have an individual row in our Market Data Input File, which are divided generally based on compliance fuel consumption value and WF.

[192] For the proposal, vehicles were divided between the LD and HDPUV fleets solely on their gross vehicle weight rating (GVWR) being above or below 8,500 lbs. We revisited the distribution of vehicles in this final rule to include the distinction for MDPVs.

[193] ''Work'' includes hauling, towing, carrying cargo, or transporting people, animals, or equipment.

[194] Manufacturers could increase their production of one type of vehicle that has higher fuel economy level, like the hybrid version of a conventional vehicle model, to meet the standards. For example, Ford has conventional, hybrid, and electric versions of its F–150 pickup truck, and Toyota has conventional, hybrid, and plug-in hybrid versions of its RAV4 sport utility vehicle.

We then organize the groups into pathways. The pathways instruct the CAFE Model how and in what order to apply technology. In other words, the pathways define technologies that are mutually exclusive (*i.e.,* that cannot be applied at the same time), and define the direction in which vehicles can advance as the model evaluates which technologies to apply. The respective technology chapters in the TSD and Section 4 of the CAFE Model Documentation for the final rule include a visual of each technology pathway. In general, the paths are tied to ease of implementation of additional technology and how closely related the technologies are.

As an example, our ''Turbo Engine Path'' consists of five different engine technologies that employ different levels of turbocharging technology. A turbocharger is essentially a small turbine that is driven by exhaust gases produced by the engine. As these gases flow through the turbocharger, they spin the turbine, which in turn spins a compressor that pushes more air into an engine's cylinder. Having more air in the engine's cylinder allows the engine to burn more fuel, which then creates more power, without needing a physically larger engine. In our analysis, an engine that uses a turbocharger ''downsizes,'' or becomes smaller. The smaller engine can use less fuel to do the same amount of work as the engine did before it used a turbocharger and was downsized. Allowing basic engines to be downsized and turbocharged instead of just turbocharged keeps the vehicle's utility and performance constant so that we can measure the costs and benefits of different levels of fuel economy improvements, rather than the change in different vehicle attributes. This concept is discussed further, below.

Grouping technologies on pathways also tells the model how to evaluate technologies; continuing this example, a vehicle can only have one engine, so if a vehicle has one of the Turbo engines the model will evaluate which more advanced Turbo technology to apply. Or, if it is more cost-effective to go beyond the Turbo pathway, the model will evaluate whether to apply more advanced engine technologies and hybridization path technology.

Then, the arrows between technologies instruct the model on the order in which to evaluate technologies on a pathway. This ensures that a vehicle that uses a more advanced technology cannot downgrade to a less advanced version of the technology, or that a vehicle would switch to technology that was significantly technically different. As an example, if a vehicle in the compliance simulation begins with a TURBOD engine—a turbocharged engine with cylinder deactivation—it cannot adopt a TURBO0 engine.[195] Similarly, this vehicle with a TURBOD engine cannot adopt an ADEACD engine.[196] As an example of our rationale for ordering technologies on the technology tree, an engine could potentially be changed from TURBO0 to TURBO2 without redesigning the engine block or requiring significantly different expertise to design and implement. A change to ADEACD would likely require a different engine block that might not be possible to fit in the engine bay of the vehicle without a complete redesign and different technical expertise requiring years of research and development. This change, which would strand capital and break parts sharing, is why the advanced engine paths restrict most movement between them. The concept of stranded capital is discussed further in Section III.C.6. The model follows instructions pursuant to the direction of arrows between technology groups and between technologies on the same pathway.

We also consider two categories of technology that we could not simulate as part of the CAFE Model's technology pathways. ''Off-cycle'' and air conditioning (AC) efficiency technologies improve vehicle fuel economy, but the benefit of those technologies cannot be captured using the fuel economy test methods that we must use under EPCA/EISA.[197] As an example, manufacturers can claim a benefit for technology like active seat ventilation and solar reflective surface coatings that make the cabin of a vehicle more comfortable for the occupants, who then do not have to use other less efficient accessories like heat or AC. Instead of including off-cycle and AC efficiency technologies in the technology pathways, we include the improvement as a defined benefit that gets applied to a manufacturer's entire fleet instead of to individual vehicles. The defined benefit that each manufacturer receives in the analysis for using off-cycle and AC efficiency technology on their vehicles is located in the Market Data Input File. See Chapter 3.7 of the TSD for more discussion in how off-cycle and AC efficiency technologies are developed and modeled.

To illustrate, throughout this section we will follow the hypothetical vehicle mentioned above that begins the compliance simulation with a TURBOD engine. Our hypothetical vehicle, Generic Motors' Ravine Runner F Series, is a roomy, top of the line sport utility vehicle (SUV). The Ravine Runner F Series starts the compliance simulation with technologies from most technology pathways; specifically, after looking at Generic Motors' website and marketing materials, we determined that it has technology that loosely fits within the following technologies that we consider in the CAFE Model: it has a turbocharged engine with cylinder deactivation, a fairly advanced 10-speed automatic transmission, a 12V start-stop system, the least advanced tire technology, a fairly aerodynamic vehicle body, and it employs a fairly advanced level of MR. We track the technologies on each vehicle using a ''technology key'', which is the string of technology abbreviations for each vehicle. Again, the vehicle technologies and their abbreviations that we consider in this analysis are shown in Table II–1 and Table II–2 above. The technology key for the Ravine Runner F Series is ''TURBOD; AT10L2; SS12V; ROLL0; AERO5; MR3.''

2. Defining Manufacturers' Current Technology Positions in the Analysis Fleet

The Market Data Input File is one of four Excel input files that the CAFE Model uses for compliance and effects simulation. The Market Data Input File's ''Vehicles'' tab (or worksheet) houses one of the most significant compilations of technology inputs and assumptions in the analysis, which is a characterization of an analysis fleet of vehicles to which the CAFE Model adds fuel economy-improving technology. We call this fleet the ''analysis fleet.'' The analysis fleet includes a number of inputs necessary for the model to add fuel economy-improving technology to each vehicle for the compliance analysis and to calculate the resulting impacts for the effects analysis.

The ''Vehicles'' tab contains a separate row for each vehicle model. For LD, vehicle models are vehicles that share the same certification fuel economy value and vehicle footprint, and for HDPUVs they are vehicles that

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[195] TURBO0 is the baseline turbocharged engine and TURBOD is TURBO0 with the addition of cylinder deactivation (DEAC). See chapter 3 of the TSD for more discussion on engine technologies.

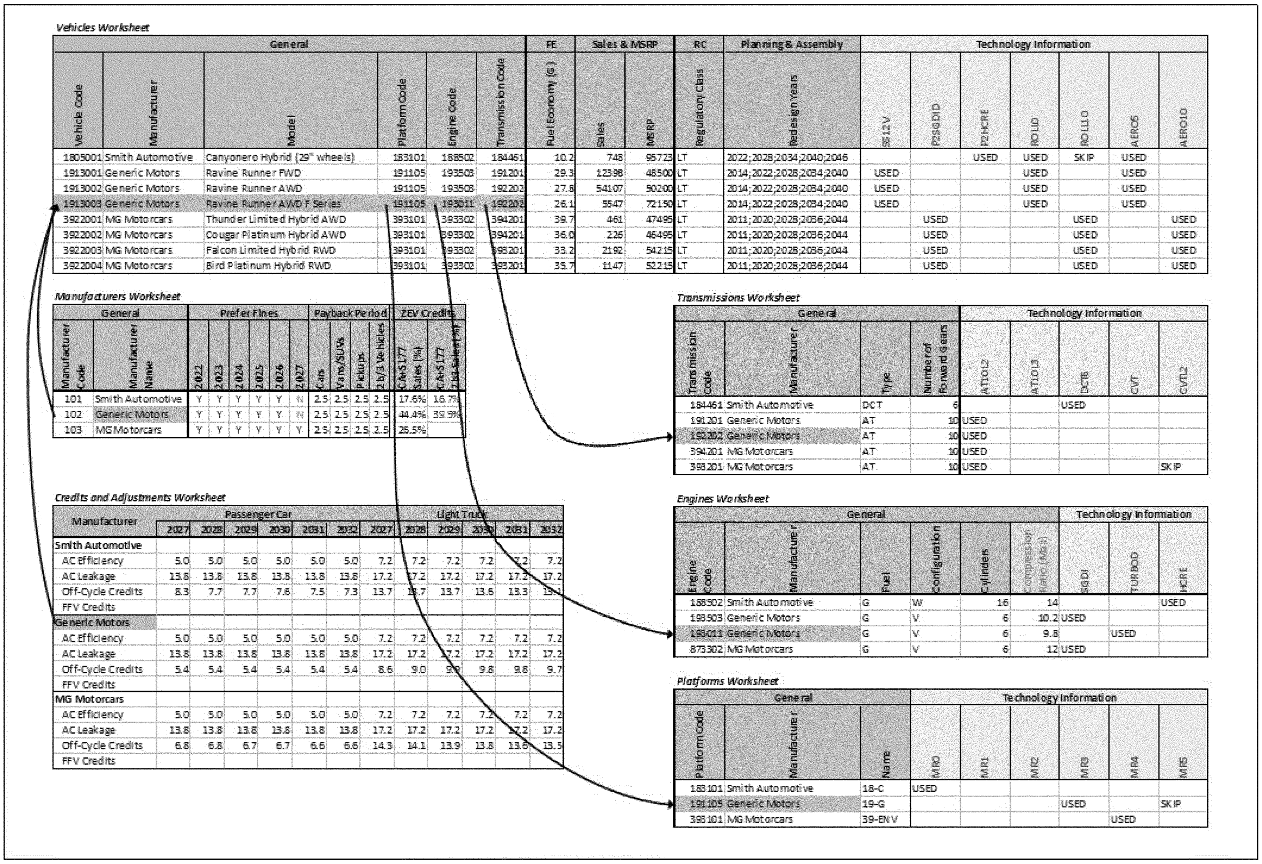
[196] ADEACD is a dual overhead camshaft engine with advanced cylindar deactivation. See chapter 3 of the TSD for more discussion on engine technologies.

[197] *See* 49 U.S.C. 32904(c) (''Testing and calculation procedures. . . . the Administrator shall use the same procedures for passenger automobiles the Administrator used for model year 1975 (weighted 55 percent urban cycle and 45 percent highway cycle), or procedures that give comparable results.'').

share the same certification fuel consumption and WF. This means that vehicle models with different configurations that affect the vehicle's certification fuel economy or fuel consumption value will be distinguished in separate rows in the Vehicles tab. For example, our Ravine Runner example vehicle comes in three different configurations—the Ravine Runner FWD, Ravine Runner AWD, and Ravine Runner F Series—which would result in three separate rows.

In each row we also designate a vehicle's engine, transmission, and platform codes.[198] Vehicles that have the same engine, transmission, or platform code are deemed to ''share'' that component in the CAFE Model. Parts sharing helps manufacturers achieve economies of scale, deploy capital efficiently, and make the most of shared research and development expenses, while still presenting a wide array of consumer choices to the market. The CAFE Model was developed to treat vehicles, platforms, engines, and transmissions as separate entities, which allows the modeling system to concurrently evaluate technology improvements on multiple vehicles that may share a common component. Sharing also enables realistic propagation, or ''inheriting,'' of previously applied technologies from an upgraded component down to the vehicle ''users'' of that component that have not yet realized the benefits of the upgrade. For additional information about the initial state of the fleet and technology evaluation and inheriting within the CAFE Model, please see Section 2.1 and Section 4.4 of the CAFE Model Documentation.

Figure III–5 below shows how we separate the different configurations of the Ravine Runner. We can see by the Platform Codes that these Ravine Runners all share the same platform, but only the Ravine Runner FWD and Ravine Runner AWD share an engine. Even so, all three certification fuel economy values are different, which is common of vehicles that differ in drive type (drive type meaning whether the vehicle has all-wheel drive (AWD), four-wheel drive (4WD), front-wheel drive (FWD), or rear-wheel drive). While it would certainly be easier to aggregate vehicles by model, ensuring that we capture model variants with different fuel economy values improves the accuracy of our analysis and the potential that our estimated costs and benefits from different levels of standards are appropriate. We include information about other vehicle technologies at the farthest right side of the Vehicles tab, and in the ''Engines'', ''Transmissions'', and ''Platforms'' worksheets, as discussed further below.



Vehicles Worksheet

General						FE	Sales & MSRP		RC	Planning & Assembly	Technology Information						
Vehicle Code	Manufacturer	Model	Platform Code	Engine Code	Transmission Code	Fuel Economy (G)	Sales	MSRP	Regulatory Class	Redesign Years	SS12V	P2SGDID	P2HCRE	ROLL0	ROLL10	AERO5	AERO10
1805001	Smith Automotive	Canyonero Hybrid (29" wheels)	183101	188502	184461	10.2	748	95723	LT	2022;2028;2034;2040;2046			USED	USED	SKIP	USED	
1913001	Generic Motors	Ravine Runner FWD	191105	193503	191201	29.3	12398	48500	LT	2014;2022;2028;2034;2040	USED			USED		USED	
1913002	Generic Motors	Ravine Runner AWD	191105	193503	192202	27.8	54107	50200	LT	2014;2022;2028;2034;2040	USED			USED		USED	
1913003	Generic Motors	Ravine Runner AWD F Series	191105	193011	192202	26.1	5547	72150	LT	2014;2022;2028;2034;2040	USED			USED		USED	
3922001	MG Motorcars	Thunder Limited Hybrid AWD	393101	393302	394201	39.7	461	47495	LT	2011;2020;2028;2036;2044		USED			USED		USED
3922002	MG Motorcars	Cougar Platinum Hybrid AWD	393101	393302	394201	36.0	226	46495	LT	2011;2020;2028;2036;2044		USED			USED		USED
3922003	MG Motorcars	Falcon Limited Hybrid RWD	393101	393302	393201	33.2	2192	54215	LT	2011;2020;2028;2036;2044		USED			USED		USED
3922004	MG Motorcars	Bird Platinum Hybrid RWD	393101	393302	393201	35.7	1147	52215	LT	2011;2020;2028;2036;2044		USED			USED		USED

Manufacturers Worksheet

General		Prefer Fines						Payback Period				ZEV Credits	
Manufacturer Code	Manufacturer Name	2022	2023	2024	2025	2026	2027	Cars	Vans/SUVs	Pickups	2b/3 Vehicles	CA+S177 Sales (%)	CA+S177 2b3 Sales (%)
101	Smith Automotive	Y	Y	Y	Y	Y	N	2.5	2.5	2.5	2.5	17.6%	16.7%
102	Generic Motors	Y	Y	Y	Y	Y	N	2.5	2.5	2.5	2.5	44.4%	39.5%
103	MG Motorcars	Y	Y	Y	Y	Y	Y	2.5	2.5	2.5	2.5	26.5%	

Credits and Adjustments Worksheet

Manufacturer	Passenger Car						Light Truck					
	2027	2028	2029	2030	2031	2032	2027	2028	2029	2030	2031	2032
Smith Automotive												
AC Efficiency	5.0	5.0	5.0	5.0	5.0	5.0	7.2	7.2	7.2	7.2	7.2	7.2
AC Leakage	13.8	13.8	13.8	13.8	13.8	13.8	17.2	17.2	17.2	17.2	17.2	17.2
Off-Cycle Credits	8.3	7.7	7.7	7.6	7.5	7.3	13.7	13.7	13.7	13.6	13.3	13.1
FFV Credits												
Generic Motors												
AC Efficiency	5.0	5.0	5.0	5.0	5.0	5.0	7.2	7.2	7.2	7.2	7.2	7.2
AC Leakage	13.8	13.8	13.8	13.8	13.8	13.8	17.2	17.2	17.2	17.2	17.2	17.2
Off-Cycle Credits	5.4	5.4	5.4	5.4	5.4	5.4	8.6	9.0	9.9	9.8	9.8	9.7
FFV Credits												
MG Motorcars												
AC Efficiency	5.0	5.0	5.0	5.0	5.0	5.0	7.2	7.2	7.2	7.2	7.2	7.2
AC Leakage	13.8	13.8	13.8	13.8	13.8	13.8	17.2	17.2	17.2	17.2	17.2	17.2
Off-Cycle Credits	6.8	6.8	6.7	6.7	6.6	6.6	14.3	14.1	13.9	13.8	13.6	13.5
FFV Credits												

Transmissions Worksheet

General				Technology Information				
Transmission Code	Manufacturer	Type	Number of Forward Gears	AT10L2	AT10L3	DCT6	CVT	CVTL2
184461	Smith Automotive	DCT	6			USED		
191201	Generic Motors	AT	10	USED				
192202	Generic Motors	AT	10	USED				
394201	MG Motorcars	AT	10	USED				
393201	MG Motorcars	AT	10	USED				SKIP

Engines Worksheet

General						Technology Information		
Engine Code	Manufacturer	Fuel	Configuration	Cylinders	Compression Ratio (Max)	SGDI	TURBOD	HCRE
188502	Smith Automotive	G	W	16	14			USED
193503	Generic Motors	G	V	6	10.2	USED		
193011	Generic Motors	G	V	6	9.8		USED	
873302	MG Motorcars	G	V	6	12	USED		

Platforms Worksheet

General			Technology Information					
Platform Code	Manufacturer	Name	MR0	MR1	MR2	MR3	MR4	MR5
183101	Smith Automotive	18-C	USED					
191105	Generic Motors	19-G				USED		SKIP
393101	MG Motorcars	39-ENV					USED	

Figure III-5: Generic Motors' Ravine Runner F Series in the Market Data Input File[199]

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[198] Each numeric engine, transmission, or platform code designates important information about that vehicle's technology; for example, a vehicle's six-digit Transmission Code includes information about the manufacturer, the vehicle's drive configuration (*i.e.,* front-wheel drive, all-wheel drive, four-wheel drive, or rear-wheel drive), transmission type, number of gears (*e.g.,* a 6-speed transmission has six gears), and the transmission variant.

[199] Note that not all data columns are shown in this example for brevity.

Moving from left to right on the Vehicles tab, after including general information about vehicles and their compliance fuel economy value, we include sales and manufacturer's suggested retail price (MSRP) data, regulatory class information (*i.e.,* domestic passenger car, import passenger car, light truck, MDPV, HD pickup truck, or HD van), and information about how we classify vehicles for the effectiveness and safety analyses. Each of these data points are important to different parts of the compliance and effects analysis, so that the CAFE Model can accurately average the technologies required across a manufacturer's regulatory classes for each class to meet its CAFE standard, or the impacts of higher fuel economy standards on vehicle sales.

In addition, we include columns indicating if a vehicle is a ''ZEV Candidate,'' which means that the vehicle could be made into a zero emissions vehicle (ZEV) at its first redesign opportunity in order to simulate a manufacturer's compliance with California's ACC I or ACT program, or manufacturer deployment of electric vehicles on a voluntary basis consistent with ACC II, which is discussed further below.

Next, we include vehicle information necessary for applying different types of technology; for example, designating a vehicle's body style means that we can appropriately apply aerodynamic technology, and designating starting curb weight values means that we can more accurately apply MR technology. Importantly, this section also includes vehicle footprint data (because we set footprint-based standards).

We also set product design cycles, which are the years when the CAFE Model can apply different technologies to vehicles. Manufacturers often introduce fuel saving technologies at a ''redesign'' of their product or adopt technologies at ''refreshes'' in between product redesigns. As an example, the redesigned third generation Chevrolet Silverado was released for the 2019 MY, and featured a new platform, updated drivetrain, increased towing capacity, reduced weight, improved safety and expanded trim levels, to name a few improvements. For MY 2022, the Chevrolet Silverado received a refresh (or facelift as it is commonly called), with an updated interior, infotainment, and front-end appearance.[200] Setting these product design cycles ensures that the CAFE Model provides manufacturers with a realistic duration of product stability between refresh and redesign cycles, and during these stability windows we assume no new fuel saving technology introductions for a given model.

During modeling, all improvements from technology application are initially realized on a component and then propagated (or inherited) down to the vehicles that share that component. As such, new component-level technologies are initially evaluated and applied to a platform, engine, or transmission during their respective redesign or refresh years. Any vehicles that share the same redesign and/or refresh schedule as the component apply these technology improvements during the same MY. The rest of the vehicles inherit technologies from the component during their refresh or redesign year (for engine- and transmission-level technologies), or during a redesign year only (for platform-level technologies). Please see Section 4.4 of the CAFE Model Documentation for additional information about technology evaluation and inheriting within the CAFE Model. We did receive comments on the refresh and redesign cycles employed in the CAFE Model, and those are discussed in detail below in Section III.C.6.

The CAFE Model also considers the potential safety effect of MR technologies and crash compatibility of different vehicle types. MR technologies lower the vehicle's curb weight, which may change crash compatibility and safety, depending on the type of vehicle. We assign each vehicle in the Market Data Input File a ''safety class'' that best aligns with the CAFE Model's analysis of vehicle mass, size, and safety, and include the vehicle's starting curb weight.[201]

The CAFE Model includes procedures to consider the direct labor impacts of manufacturers' response to CAFE regulations, considering the assembly location of vehicles, engines, and transmissions, the percent U.S. content (that reflects percent U.S. and Canada content), and the dealership employment associated with new vehicle sales. Estimated labor information, by vehicle, is included in the Market Data Input File. Sales volumes included in and adapted from the market data also influence total estimated direct labor projected in the analysis. See Chapter 6.2.5 of the TSD for further discussion of the labor utilization analysis.

We then assign the CAFE Model's range of technologies to individual vehicles. This initial linkage of vehicle technologies is how the CAFE Model knows how to advance a vehicle down each technology pathway. Assigning CAFE Model technologies to individual vehicles is dependent on the mix of information we have about any particular vehicle and trends about how a manufacturer has added technology to that vehicle in the past, equations and models that translate real-world technologies to their counterparts in our analysis (*e.g.,* drag coefficients and body styles can be used to determine a vehicle's AERO level), and our engineering judgment.

As discussed further below, we use information directly from manufacturers to populate some fields in the Market Data Input File, like vehicle horsepower ratings and vehicle weight. We also use manufacturer data as an input to various other models that calculate how a manufacturer's real-world technology equates to a technology level in our model. For example, we calculate initial MR, aerodynamic drag reduction, and ROLL levels by looking at industry-wide trends and calculating—through models or equations—levels of improvement for each technology. The models and algorithms that we use are described further below and in detail in Chapter 3 of the TSD. Other fields, like vehicle refresh and redesign years, are projected forward based on historic trends.

Let us return to the Ravine Runner F Series with the technology key ''TURBOD; AT10L2, SS12V; ROLL0; AERO5; MR3.'' Generic Motor's publicly available spec sheet for the Ravine Runner F Series says that the Ravine Runner F Series uses Generic Motor's Turbo V6 engine with proprietary Adaptive Cylinder Management Engine (ACME) technology. ACME improves fuel economy and lowers emissions by operating the engine using only three of the engine's cylinders in most conditions and using all six engine cylinders when more power is required. Generic Motors uses this engine in several of their vehicles, and the specifications of the engine can be found in the Engines Tab of the Market Data Input File, under a six-digit engine code.[202]

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[200] GM Authority. 2022 Chevy Silverado. Available at: *https://gmauthority.com/blog/gm/chevrolet/silverado/2022-chevrolet-silverado/.* (Accessed May 31, 2023).

[201] Vehicle curb weight is the weight of the vehicle with all fluids and components but without the drivers, passengers, and cargo.

[202] Like the Transmission Codes discussed above, the Engine Codes include information identifying the manufacturer, engine displacement (*i.e.,* how many liters the engine is), whether the engine is naturally aspirated or force inducted (*e.g.,* turbocharged), and whether the engine has any other unique attributes.

This is a relatively easy engine to assign based on publicly available specification sheets, but some technologies are more difficult to assign. Manufacturers use different trade names or terms for different technology, and the way that we assign the technology in our analysis may not necessarily line up with how a manufacturer describes the technology. We must use some engineering judgment to determine how discrete technologies in the market best fit the technology options that we consider in our analysis. We discuss factors that we use to assign each vehicle technology in the individual technology subsections below.

In addition to the Vehicles Tab that houses the analysis fleet, the Market Data Input File includes information that affects how the CAFE Model might apply technology to vehicles in the compliance simulation. Specifically, the Market Data Input File's "Manufacturers" tab includes a list of vehicle manufacturers considered in the analysis and several pieces of information about their economic and compliance behavior. First, we determine if a manufacturer "prefers fines," meaning that historically in the LD fleet, we have observed this manufacturer paying civil penalties for failure to meet CAFE standards.[203] We might designate a manufacturer as not preferring fines if, for example, they have told us that paying civil penalties would be a violation of provisions in their corporate charter. For the NPRM analysis, we assumed that all manufacturers were willing to pay fines in MYs 2022–2026, and that in MY 2027 and beyond, only the manufacturers that had historically paid fines would continue to pay fines. We sought comment on fine payment preference assumptions. Jaguar Land Rover NA commented that they do "not view fine payment as an appropriate compliance route or as a flexibility in the regulation." [204] In response to JLR's comment, NHTSA has changed their fine preference in the analysis from "prefer fines" to "not prefer fines" for MYs 2027 and beyond. Ford and the Alliance also commented on not using fines for HDPUV compliance.[205] Both commenters agreed with NHTSA's approach of not including fines in the HDPUV analysis. NHTSA maintained the same approach from the NPRM for this final rule and intends to do so in the future.

However, as further discussed below in regard to the CAFE Model's compliance simulation algorithm in Section III.C.6, note that the model will still apply technologies for these manufacturers if it is cost-effective to do so, as defined by several variables.

Next, we designate a "payback period" for each manufacturer. The payback period represents an assumption that consumers are willing to buy vehicles with more fuel economy technology because the fuel economy technology will save them money on gas in the long run. For the past several CAFE Model analyses we have assumed that in the absence of CAFE or other regulatory standards, manufacturers would apply technology that "pays for itself"—by saving the consumer money on fuel—in 2.5 years. While the amount of technology that consumers are willing to pay for is subject to much debate, we continue to assume a 2.5-year payback period based on what manufacturers have told us they do, and on estimates in the available literature. This is discussed in detail in Section III.E below, and in the TSD and FRIA.

We also designate in the Market Data Input File the percentage of each manufacturer's sales that must meet Advanced Clean Car I requirements in certain states, and percentages of sales that manufacturers are expected to produce consistent with levels that would be required under the Advanced Clean Cars II program, if it were to be granted a Clean Air Action preemption waiver. Section 209(a) of the CAA generally preempts states from adopting emission control standards for new motor vehicles; however, Congress created an exemption program in section 209(b) that allows the State of California to seek a waiver of preemption. EPA must grant the waiver unless the Agency makes one of three statutory findings.[206] Under CAA section 177, other States can adopt and enforce standards identical those approved under California's section 209(b) waiver.

Finally, we include estimated CAFE compliance credit banks for each manufacturer in several years through 2021, which is the year before the compliance simulation begins. The CAFE Model does not explicitly simulate credit trading between and among vehicle manufacturers, but we estimate how manufacturers might use compliance credits in early MYs. This reflects manufacturers' tendency to use regulatory credits as an alternative to applying technology.[207]

Before we begin building the Market Data Input File for any analysis, we must consider what MY vehicles will comprise the analysis fleet. There is an inherent time delay in the data we can use for any particular analysis because we must set LD CAFE standards at least 18 months in advance of a MY if the CAFE standards increase,[208] and HDPUV fuel efficiency standards at least 4 full MYs in advance if the standards increase.[209] In addition to the requirement to set standards at least 18 months in advance of a MY, we must propose standards with enough time to allow the public to comment on the proposed standards and meaningfully evaluate that feedback and incorporate it into the final rule in accordance with the APA.[210] This means that the most recent data we have available to generate the analysis fleet necessarily falls behind the MY fleets of vehicles for which we generate standards.

Using recent data for the analysis fleet is more likely to reflect the current vehicle fleet than older data. Recent data will inherently include manufacturer's realized decisions on what fuel economy-improving technology to apply, mix shifts in response to consumer preferences (*e.g.,* more recent data reflects manufacturer and consumer preference towards larger vehicles),[211] and industry sales volumes that incorporate substantive macroeconomic events (*e.g.,* the impact of the Coronavirus disease of 2019 (COVID) or microchip shortages). We considered that using an analysis fleet year that has been impacted by these transitory shocks may not represent trends in future years; however, on balance, we believe that updating to using the most complete set of available fleet data provides the most accurate analysis fleet for the CAFE Model to calculate compliance and effects of different levels of future fuel economy

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[203] *See* 49 U.S.C. 32912.

[204] Jaguar, Docket No. NHTSA–2023–0022–57296, at 5.

[205] Ford, Docket No. NHTSA–2023–0022–60837, at 8; The Alliance, Docket No. NHTSA–2023–0022–60652–A5, at 63–64.

[206] *See* 87 FR 14332 (March 14, 2022). ("The CAA section 209(b) waiver is limited "to any State which has adopted standards . . . for the control of emissions from new motor vehicles or new motor vehicle engines prior to March 30, 1966," and California is the only State that had standards in place before that date.").

[207] Note, this is just an observation about manufacturers' tendency to use regulatory credits rather than to apply technology; in accordance with 49 U.S.C. 32902(h), the CAFE Model does not simulate a manufacturer's potential credit use during the years for which we are setting new CAFE standards.

[208] 49 U.S.C. 32902(a).

[209] 49 U.S.C. 32902(k)(3)(A).

[210] 5 U.S.C. 553.

[211] See EPA. 2023. The 2023 EPA Automotive Trends Report, Greenhouse Gas Emissions, Fuel Economy, and Technology since 1975. EPA–420–R–23–033. at 14–19. *hereinafter* the 2023 EPA Automotive Trends Report.

standards. Also, using recent data decreases the likelihood that the CAFE Model selects compliance pathways for future standards that affect vehicles already built in previous MYs.[212]

At the time we start building the analysis fleet, data that we receive from vehicle manufacturers in accordance with EPCA/EISA,[213] and our CAFE compliance regulations in advance of or during an ongoing MY,[214] offers the best snapshot of vehicles for sale in the US in a MY. These pre-model year (PMY) and mid-model year (MMY) reports include information about individual vehicles at the vehicle configuration level. We use the vehicle configuration, certification fuel economy, sales, regulatory class, and some additional technology data from these reports as the starting point to build a ''row'' (*i.e.,* a vehicle configuration, with all necessary information about the vehicle) in the Market Data Input File's Vehicle's Tab. Additional technology data come from publicly available information, including vehicle specification sheets, manufacturer press releases, owner's manuals, and websites. We also generate some assumptions in the Market Data Input File for data fields where there is limited data, like refresh and redesign cycles for future MYs, and technology levels for certain road load reduction technologies like MR and aerodynamic drag reduction.

For this analysis, the LD analysis fleet consists of every vehicle model in MY 2022 in nearly every configuration that has a different compliance fuel economy value, which results in more than 2,000 individual rows in the Vehicles Tab of the Market Data Input File. The HDPUV fleet consists of vehicles produced in between MYs 2014 and 2022, which results in a little over 1100 individual rows in the HDPUV Market Data Input File. We used a combination of MY data for that fleet because of data availability, but the resulting dataset is a robust amalgamation that provides a reasonable starting point for the much smaller fleet.

Rivian and ZETA commented that some of Rivian's vehicles were misclassified between the light-duty and HDPUV analysis fleets.[215] NHTSA was aware that some manufacturer's vehicles were erroneously included in the HDPUV fleet rather than the LD fleet. NHTSA stated in the TSD that ''for this NPRM, vehicles were divided between light-duty and HDPUV solely on GVWR being above or below 8,500 lbs.'' and that ''the following will be reassigned to the LD fleet in the final rule: all Rivian vehicles.'' Per Rivian's further clarification, NHTSA has reassigned all of Rivian's vehicles in accordance with their comments. NHTSA has also reassigned Ford F150 Lightnings and some Ford Transit Wagons to the LD fleet.

The Ford vehicles moved represent 3,199 total sales out of 1.6 million LD and 319.5 thousand HDPUV sales. The re-classification of Ford's and Rivian's vehicles does not materially affect the analysis results. Ford's vehicles moved represented a very small volume of either fleet, and each regulatory class is regulated based on average performance thus resulting in minor differences of manufacturer's compliance position in each analysis. Moving Rivian's vehicles does not materially affect the analysis results either because they always exceed the regulatory standards, in either fleet. Their vehicles are all electric and outperform the standards every year, regardless of which fleet they find themselves in. Their vehicles will have different technologies available to them in the LD fleet and thus the actual solution will vary. The average costs and pollutant levels of each regulatory class will have changed subtly as a result of moving the vehicles from one fleet to another, but their changes were also affected by the different preferred alternative. The only circumstance in which Rivian's inclusion in one fleet or another could materially sway the outcome is if we modeled credit trading between manufacturers, which is an analysis that EPCA/EISA restricts NHTSA from doing, as discussed further elsewhere in this preamble.

Furthermore, Rivian, ZETA, and Tesla commented about the lack of inclusion of Rivian's Class 2b vans and Tesla's Cybertruck.[216] Rivian stated that in the case of the HDPUV program, ''omitting Rivian's Class 2b vans could have material implications for the agency's final'' regulation. Rivian also further explained these comments to the agency in a meeting on October 12, 2023.[217] Tesla's Cybertruck is a 2023 or 2024 MY vehicle and the compliance data for that vehicle—which is essential to accurately characterizing the vehicle in the analysis fleet—was not available to the agency at the time of analysis. Rivian's electric delivery van launched in MY 2022 but the compliance data was not available to NHTSA at the time of fleet development.

NHTSA does not believe that the HDPUV analysis would change materially with the inclusion of Rivian's Class 2b vans or Tesla's Cybertruck. Both manufacturers would be able to demonstrate compliance with any stringency in that analysis, and their inclusion would not affect other manufacturers' ability to comply with their standards. This is because, once again, the analysis does not perform any form of credit trading between manufacturers and thus would not have allowed for other manufacturers to comply with higher stringencies. While NHTSA does examine the industry average performance when setting standards, NHTSA also looks at individual manufacturer performance with the standards as well. NHTSA discusses the results of the final HDPUV analysis in Section V. NHTSA will be happy to include all available manufacturers in any future analysis fleets if compliance data is available at the time the fleet is being developed.

The next section discusses how our analysis evaluates how adding additional fuel economy-improving technology to a vehicle in the analysis fleet will improve that vehicle's fuel economy value. Put another way, the next section answers the question, how do we estimate how effective any given technology is at improving a vehicle's fuel economy value?

3. Technology Effectiveness Values

How does the CAFE Model know how effective any particular technology is at improving a vehicle's fuel economy value? Accurate technology effectiveness estimates require information about: (1) the vehicle type and size; (2) the other technologies on the vehicle and/or being added to the vehicle at the same time; and (3) and how the vehicle is driven. Any oversimplification of these complex factors could make the effectiveness estimates less accurate.

To build a database of technology effectiveness estimates that includes these factors, we partner with the DOE's Argonne National Laboratory (Argonne).

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[212] For example, in this analysis the CAFE Model must apply technology to the MY 2022 fleet from MYs 2023–2026 for the compliance simulation that begins in MY 2027 (for the light-duty fleet), and from MYs 2023–2029 for the compliance simulation that begins in MY 2030 (for the HDPUV fleet). While manufacturers have already built MY 2022 and later vehicles, the most current, complete dataset with regulatory fuel economy test results to build the analysis fleet at the time of writing remains MY 2022 data for the light-duty fleet, and a range of MYs between 2014 and 2022 for the HDPUV fleet.

[213] 49 U.S.C. 32907(a)(2).

[214] 49 CFR part 537.

[215] Rivian, Docket No. NHTSA–2023–0022–59765, at 5–8; ZETA, Docket No. NHTSA–2023–0022–60508, at 28.

[216] ZETA, Docket No. NHTSA–2023–0022–60508, at 29; Rivian, Docket No. NHTSA–2023–0022–59765, at 7–8; Tesla, Docket No. NHTSA–2023–0022–60093, at 6.

[217] Docket Memo of Ex Parte Meeting with Rivian.

Argonne has developed and maintains a physics-based full-vehicle modeling and simulation tool called Autonomie that generates technology effectiveness estimates for the CAFE Model.

What is physics-based full-vehicle modeling and simulation? A model is a mathematical representation of a system, and simulation is the behavior of that mathematical representation over time. The Autonomie model is a mathematical representation of an entire vehicle, including its individual technologies such as the engine and transmission, overall vehicle characteristics such as mass and aerodynamic drag, and the environmental conditions, such as ambient temperature and barometric pressure.

We simulate a vehicle model's behavior over the ''two-cycle'' tests that are used to measure vehicle fuel economy.[218] For readers unfamiliar with this process, measuring a vehicle's fuel economy on the two-cycle tests is like running a car on a treadmill following a program—or more specifically, two programs. The ''programs'' are the ''urban cycle,'' or Federal Test Procedure (abbreviated as ''FTP''), and the ''highway cycle,'' or Highway Fuel Economy Test (abbreviated as ''HFET''). For the FTP drive cycle the vehicle meets certain speeds at certain times during the test, or in technical terms, the vehicle must follow the designated ''speed trace.''[219] The FTP is meant roughly to simulate stop and go city driving, and the HFET is meant roughly to simulate steady flowing highway driving at about 50 miles per hour (mph). We also use the Society of Automotive Engineers (SAE) recommended practices to simulate hybridized and EV drive cycles,[220] which involves the test cycles mentioned above and additional test cycles to measure battery energy consumption and range.

Measuring every vehicle's fuel economy values using the same test cycles ensures that the fuel economy certification results are repeatable for each vehicle model, and comparable across all of the different vehicle models. When performing physical vehicle cycle testing, sophisticated test and measurement equipment calibrated according to strict industry standards further ensures repeatability and comparability of the results. This can include dynamometers, environmental conditions, types and locations of measurement equipment, and precise testing procedures. These physical tests provide the benchmarking empirical data used to develop and verify Autonomie's vehicle control algorithms and simulation results. Autonomie's inputs are discussed in more detail later in this section.

Finally, ''physics-based'' simply refers to the mathematical equations underlying the modeling and simulation—the simulated vehicle models and all of the sub-models that make up specific vehicle components and the calculated fuel used on simulated test cycles are calculated mathematical equations that conform to the laws of physics.

Full-vehicle modeling and simulation was initially developed to avoid the costs of designing and testing prototype parts for every new type of technology. For example, Generic Motors can use physics-based computer modeling to determine the fuel economy penalty for adding a 4WD, rugged off-road tire trim level of the Ravine Runner to its lineup. The Ravine Runner, modeled with its new drivetrain and off-road tires, can be simulated on a defined test route and under defined test conditions and compared against the initial Ravine Runner simulated without the change. Full-vehicle modeling and simulation allows Generic Motors to consider and evaluate different designs and concepts before building a single prototype for any potential technology change.

Full vehicle modeling and simulation is also essential to measuring how all technologies on a vehicle interact. For example, if technology A improves a particular vehicle's fuel economy by 5% and technology B improves a particular vehicle's fuel economy by 10%, an analysis using single or limited point estimates may erroneously assume that applying both of these technologies together would achieve a simple additive fuel economy improvement of 15%. Single point estimates generally do not provide accurate effectiveness values because they do not capture complex relationships among technologies. Technology effectiveness often differs significantly depending on the vehicle type (*e.g.,* sedan versus pickup truck) and the way in which the technology interacts with other technologies on the vehicle, as different technologies may provide different incremental levels of fuel economy improvement if implemented alone or in combination with other technologies. As stated above, any oversimplification of these complex factors could lead to less accurate technology effectiveness estimates.

In addition, because manufacturers often add several fuel-saving technologies simultaneously when redesigning a vehicle, it is difficult to isolate the effect of adding any one individual technology to the full vehicle system. Modeling and simulation offer the opportunity to isolate the effects of individual technologies by using a single or small number of initial vehicle configurations and incrementally adding technologies to those configurations. This provides a consistent reference point for the incremental effectiveness estimates for each technology and for combinations of technologies for each vehicle type. Vehicle modeling also reduces the potential for overcounting or undercounting technology effectiveness.

Argonne does not build an individual vehicle model for every single vehicle configuration in our LD and HDPUV Market Data Input Files. This would be nearly impossible, because Autonomie requires very detailed data on hundreds of different vehicle attributes (like the weight of the vehicle's fuel tank, the weight of the vehicle's transmission housing, the weight of the engine, the vehicle's 0–60 mph time, and so on) to build a vehicle model, and for practical reasons we cannot acquire 4000 vehicles and obtain these measurements every time we promulgate a new rule (and we cannot acquire vehicles that have not yet been built). Rather, Argonne builds a discrete number of vehicle models that are representative of large portions of vehicles in the real world. We refer to the vehicle model's type and performance level as the vehicle's ''technology class.'' By assigning each vehicle in the Market Data Input File a ''technology class,'' we can connect it to the Autonomie effectiveness estimate that best represents how effective the technology would be on the vehicle, taking into account vehicle characteristics like type and performance metrics. Because each vehicle technology class has unique characteristics, the effectiveness of technologies and combinations of technologies is different for each technology class.

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[218] We are statutorily required to use the two-cycle tests to measure vehicle fuel economy in the CAFE program. See 49 U.S.C. 32904(c) (''Testing and calculation procedures . . . . the Administrator shall use the same procedures for passenger automobiles the Administrator used for model year 1975 (weighted 55 percent urban cycle and 45 percent highway cycle), or procedures that give comparable results.'').

[219] EPA. 2023. Emissions Standards Reference Guide. EPA Federal Test Procedure (FTP). Available at: *https://www.epa.gov/emission-standards-reference-guide/epa-federal-test-procedure-ftp.* (Accessed: Feb. 27, 2024).

[220] SAE. 2023. Recommended Practice for Measuring the Exhaust Emissions and Fuel Economy of Hybrid-Electric Vehicles, Including Plug-in Hybrid Vehicles. SAE Standard J1711. Rev. Feb 2023.; SAE. 2021. Battery Electric Vehicle Energy Consumption and Range Test Procedure. SAE Standard J1634. Rev. April 2021.

There are ten technology classes for the LD analysis: small car (SmallCar), small performance car (SmallCarPerf), medium car (MedCar), medium performance car (MedCarPerf), small SUV (SmallSUV), small performance SUV (SmallSUVPerf), medium SUV (MedSUV), medium performance SUV (MedSUVPerf), pickup truck (Pickup), and high towing pickup truck (PickupHT). There are four technology classes for the HDPUV analysis, based on the vehicle's ''weight class.'' An HDPUV that weighs between 8,501 and 10,000 pounds is in ''Class 2b,'' and an HDPUV that weighs between 10,001 and 14,000 pounds is in ''Class 3.'' Our four HDPUV technology classes are Pickup2b, Pickup3, Van2b, and Van3.

We use a two-step process that involves two algorithms to give vehicles a ''fit score'' that determines which vehicles best fit into each technology class. At the first step we determine the vehicle's size, and at the second step we determine the vehicle's performance level. Both algorithms consider several metrics about the individual vehicle and compare that vehicle to other vehicles in the analysis fleet. This process is discussed in detail in TSD Chapter 2.2.

Consider our Ravine Runner F Series, which is a medium-sized performance SUV. The exact same combination of technologies on the Ravine Runner F Series will operate differently in a compact car or pickup truck because they are different vehicle sizes. Our Ravine Runner F Series also achieves slightly better performance metrics than other medium-sized SUVs in the analysis fleet. When we say, ''performance metrics,'' we mean power, acceleration, handing, braking, and so on, but for the performance fit score algorithm, we consider the vehicle's estimated 0–60 mph time compared to an initial 0–60 mph time for the vehicle's technology class. Accordingly, the ''technology class'' for the Ravine Runner F Series in our analysis is ''MedSUVPerf''.

Table III–1 shows how vehicles in different technology classes that use the exact same fuel economy technology have very different absolute fuel economy values. Note that, as discussed further below, the Autonomie absolute fuel economy values are not used directly in the CAFE Model; we calculate the ratio between two Autonomie absolute fuel economy values (one for each technology key for a specific technology class) and apply that ratio to an analysis fleet vehicle's starting fuel economy value.

Table III-1: Examples of Technology Class Differences

Technology Class and Technology Key	Autonomie Absolute Fuel Economy Value (mpg)
MedSUVPerf TURBOD; AT10L2, SS12V; ROLL0; AERO5; MR3	30.8
MedSUV TURBOD; AT10L2, SS12V; ROLL0; AERO5; MR3	34.9
CompactPerf TURBOD; AT10L2, SS12V; ROLL0; AERO5; MR3	42.2
Pickup TURBOD; AT10L2, SS12V; ROLL0; AERO5; MR3	29.7

Let us also return to the concept of what we call technology synergies. Again, depending on the technology, when two technologies are added to the vehicle together, they may not result in an additive fuel economy improvement. This is an important concept to understand because in Section III.D, below, we present technology effectiveness estimates for every single combination of technology that could be applied to a vehicle. In some cases, technology effectiveness estimates show that a combined technology has a different effectiveness estimate than if the individual technologies were added together individually. However, this is expected and not an error. Continuing our example from above, turbocharging technology and DEAC technology both improve fuel economy by reducing the engine displacement, and accordingly burning less fuel. Turbocharging allows a larger naturally aspirated engine to be reduced in size or displacement while still doing the same amount of work, and its fuel efficiency improvements are, in part, due to the reduced displacement. DEAC effectively makes an engine with a particular displacement intermittently offer some of the fuel economy benefits of a smaller-displacement engine by deactivating cylinders when the work demand does not require the full engine displacement and reactivating them as-needed to meet higher work demands; the greater the displacement of the deactivated cylinders, the greater the fuel economy benefit. Therefore, a manufacturer upgrading to an engine that uses both a turbocharger and DEAC technology, like the TURBOD engine in our example above, would not see the full combined fuel economy improvement from that specific combination of technologies. Table III–2 shows a vehicle's fuel economy value when using the first-level DEAC technology and when using the first-level turbocharging technology, compared to our vehicle that uses both of those technologies combined with a TURBOD engine.

Table III-2: Example of Technology Synergies

MedSUVPerf Technology Key	Autonomie Absolute Fuel Economy Value (mpg)
DOHC; SGDI; AT10L2; SS12V; ROLL0; AERO5; MR3	28.6
DOHC; SGDI; DEAC; AT10L2; SS12V; ROLL0; AERO5; MR3	29.1
TURBO0; AT10L2; SS12V; ROLL0; AERO5; MR3	30.7
TURBOD; AT10L2; SS12V; ROLL0; AERO5; MR3	30.8

As expected, the percent improvement in Table III–2 between the first and second rows is 1.7% and between the third and fourth rows is 0.3%, even though the only difference within the two sets of technology keys is the DEAC technology (note that we only compare technology keys within the same technology class). This is because there are complex interactions between all fuel economy-improving technologies. We model these individual technologies and groups of technologies to reduce the uncertainty and improve the accuracy of the CAFE Model outputs.

Some technology synergies that we discuss in Section III.D include advanced engine and hybrid powertrain technology synergies. As an example, we do not see a particularly high effectiveness improvement from applying advanced engines to existing parallel strong hybrid (*i.e.,* P2) architectures.[221] In this instance, the P2 powertrain improves fuel economy, in part, by allowing the engine to spend more time operating at efficient engine speed and load conditions. This reduces the advantage of adding advanced engine technologies, which also improve fuel economy, by broadening the range of speed and load conditions for the engine to operate at high efficiency. This redundancy in fuel savings mechanism results in a lower effectiveness when the technologies are added to each other. Again, we intend and expect that different combinations of technologies will provide different effectiveness improvements on different vehicle types. These examples all illustrate relationships that we can only observe using full vehicle modeling and simulation.

Just as our CAFE Model analysis requires a large set of technology inputs and assumptions, the Autonomie modeling uses a large set of technology inputs and assumptions. Figure III–6 below shows the suite of fuel consumption input data used in the Autonomie modeling to generate the fuel consumption input data we use in the CAFE Model.

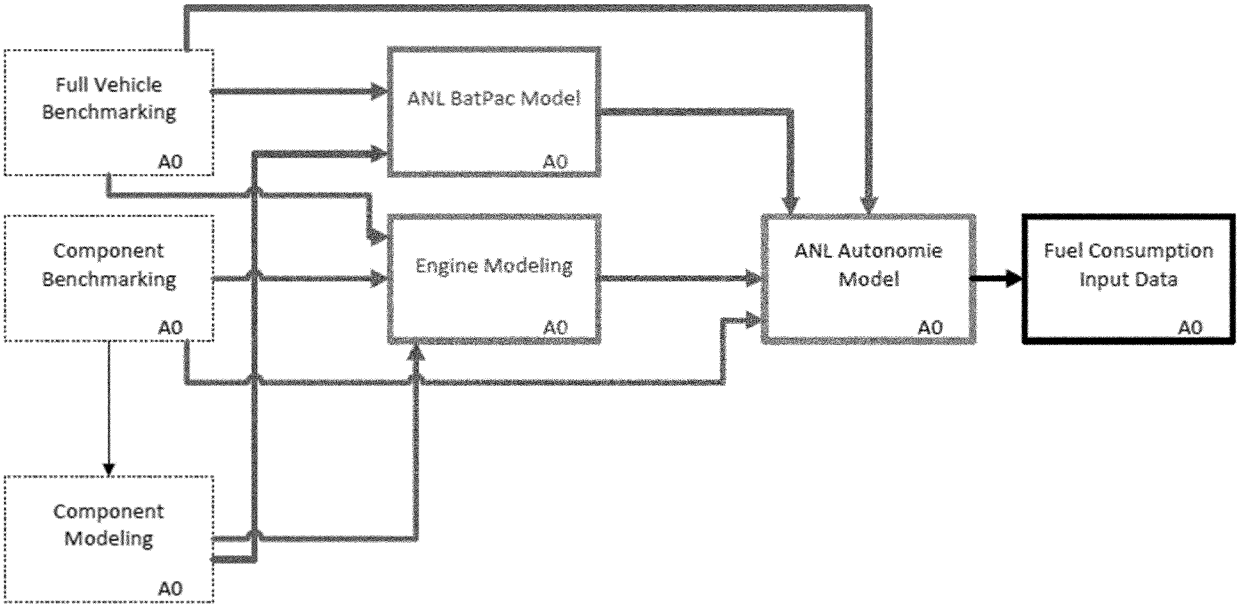

Figure III-6: Fuel Consumption Input Data Used in the Autonomie Modeling

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[221] A parallel strong hybrid powertrain is fundamentally similar to a conventional powertrain but adds one electric motor to improve efficiency. TSD Chapter 3 shows all of the parallel strong hybrid powertrain options we model in this analysis.

What are each of these inputs? For full vehicle benchmarking, vehicles are instrumented with sensors and tested both on the road and on chassis dynamometers (*i.e.,* the car treadmills used to calculate vehicle's fuel economy values) under different conditions and duty cycles. Some examples of full vehicle benchmark testing we did in conjunction with our partners at Argonne in anticipation of this rule include a 2019 Chevrolet Silverado, a 2021 Toyota Rav4 Prime, a 2022 Hyundai Sonata Hybrid, a 2020 Tesla Model 3, and a 2020 Chevrolet Bolt.[222] We produced a report for each vehicle benchmarked which can be found in the docket. As discussed further below, that full vehicle benchmarking data are used as inputs to the engine modeling and Autonomie full vehicle simulation modeling. Component benchmarking is like full vehicle benchmarking, but instead of testing a full vehicle, we instrument a single production component or prototype component with sensors and test it on a similar duty cycle as a full vehicle. Examples of components we benchmark include engines, transmissions, axles, electric motors, and batteries. Component benchmarking data are used as an input to component modeling, where a production or prototype component is changed in fit, form and/or function and modeled in the same scenario. As an example, we might model a decrease in the size of holes in fuel injectors to see the fuel atomization impact or see how it affects the fuel spray angle.

We use a range of models to do the component modeling for our analysis. As shown in Figure III–6, battery pack modeling using Argonne's BatPaC Model and engine modeling are two of the most significant component models used to generate data for the Autonomie modeling. We discuss BatPaC in detail in Section II.D, but briefly, BatPaC is the battery pack modeling tool we use to estimate the cost of vehicle battery packs based on the materials chemistry, battery design, and manufacturing design of the plants manufacturing the battery packs.

Engine modeling is used to generate engine fuel map models that define the fuel consumption rate for an engine equipped with specific technologies when operating over a variety of engine load and engine speed conditions. Some performance metrics we capture in engine modeling include power, torque, airflow, volumetric efficiency, fuel consumption, turbocharger performance and matching, pumping losses, and more. Each engine map model has been developed ensuring the engine will still operate under real-world constraints using a suite of other models. Some examples of these models that ensure the engine map models capture real-world operating constraints include simulating heat release through a predictive combustion model, knock characteristics through a kinetic fit knock model,[223] and using physics-based heat flow and friction models, among others. We simulate these constraints using data gathered from component benchmarking, and engineering and physics calculations.

The engine map models are developed by creating a base, or root, engine map and then modifying that root map, incrementally, to isolate the effects of the added technologies. The LD engine maps, developed by IAV using their GT-Power modeling tool and the HDPUV engine maps, developed by SwRI using their GT-Power modeling tool, are based on real-world engine designs. One important feature of both the LD and HDPUV engine maps is that they were both developed using a knock model. As noted above, a knock model ensures that any engine size or specification that we model in the analysis does not result in engine knock, which could damage engine components in a real-world vehicle. Although the same engine map models are used for all vehicle technology classes, the effectiveness varies based on the characteristics of each class. For example, as discussed above, a compact car with a turbocharged engine will have a different effectiveness value than a pickup truck with the same engine technology type. The engine map model development and specifications are discussed further in Chapter 3 of the TSD.

Argonne also compiles a database of vehicle attributes and characteristics that are reasonably representative of the vehicles in that technology class to build the vehicle models. Relevant vehicle attributes may include a vehicle's fuel efficiency, emissions, horsepower, 0–60 mph acceleration time, and stopping distance, among others, while vehicle characteristics may include whether the vehicle has all-wheel-drive, 18-inch wheels, summer tires, and so on. Argonne identified representative vehicle attributes and characteristics for both the LD and HDPUV fleets from publicly available information and automotive benchmarking databases such as A2Mac1,[224] Argonne's Downloadable Dynamometer Database (D^3),[225] EPA compliance and fuel economy data,[226] EPA's guidance on the cold start penalty on 2-cycle tests,[227] the 21st Century Truck Partnership,[228] and industry partnerships.[229] The resulting vehicle technology class baseline assumptions and characteristics database consists of over 100 different attributes like vehicle height and width and weights for individual vehicle parts.

Argonne then assigns ''reference'' technologies to each vehicle model. The reference technologies are the technologies on the first step of each CAFE Model technology pathway, and they closely (but do not exactly) correlate to the technology abbreviations that we use in the CAFE Model. As an example, the first Autonomie vehicle model in the ''MedSUVPerf'' technology class starts out with the least advanced engine, which is ''DOHC'' (a dual overhead cam engine) in the CAFE Model, or ''eng01'' in the Autonomie modeling. The vehicle has the least advanced transmission, AT5, the least

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[222] For all Argonne National Labs full vehicle benchmarking reports, see Docket No. NHTSA–2023–0022–0010.

[223] Engine knock occurs when combustion of some of the air/fuel mixture in the cylinder does not result from propagation of the flame front ignited by the spark plug, but one or more pockets of air/fuel mixture explodes outside of the envelope of the normal combustion front. Engine knock can result in unsteady operation and damage to the engine.

[224] A2Mac1: Automotive Benchmarking. (Proprietary data). Available at: *https://www.a2mac1.com.* (Accessed: May 31, 2023). A2Mac1 is subscription-based benchmarking service that conducts vehicle and component teardown analyses. Annually, A2Mac1 removes individual components from production vehicles such as oil pans, electric machines, engines, transmissions, among the many other components. These components are weighed and documented for key specifications which is then available to their subscribers.

[225] Argonne National Laboratory. 2023. Downloadable Dynamometer Database (D^3). Argonne National Laboratory, Energy Systems Division. Available at: *https://www.anl.gov/es/downloadable-dynamometer-database.* (Accessed: Feb. 27, 2024).

[226] EPA. 2023. Data on Cars Used for Testing Fuel Economy. EPA Compliance and Fuel Economy Data. Available at: *https://www.epa.gov/compliance-and-fuel-economy-data/data-cars-used-testing-fuel-economy.* (Accessed: Feb. 27, 2024).

[227] EPA PD TSD at 2–265–2–266.

[228] DOE. 2019. 21st Century Truck Partnership Research Blueprint. Available at: *https://www.energy.gov/sites/default/files/2019/02/f59/21CTPResearchBlueprint2019_FINAL.pdf.* (Accessed: Feb. 27, 2024); DOE. 2023. 21st Century Truck Partnership. Available at: *https://www.energy.gov/eere/vehicles/21st-century-truck-partnership.* (Accessed: Feb. 23, 2024); National Academies of Sciences, Engineering, and Medicine. 2015. Review of the 21st Century Truck Partnership, Third Report. *The National Academies Press.* Washington, DC. Available at: *https://nap.nationalacademies.org/catalog/21784/review-of-the-21st-century-truck-partnership-third-report.* (Accessed: Feb. 23, 2024).

[229] North American Council for Freight Efficiency. Research and analysis. *https://www.nacfe.org/research/overview/.* (Accessed: Feb. 23, 2024).

advanced MR level, MR0, the least advanced aerodynamic body style, AERO0, and the least advanced ROLL level, ROLL0. The first vehicle model is also defined by initial vehicle attributes and characteristics that consist of data from the suite of sources mentioned above. Again, these attributes are meant to reasonably represent the average of vehicle attributes found on vehicles in a certain technology class.

Then, just as a vehicle manufacturer tests its vehicles to ensure they meet specific performance metrics, Autonomie ensures that the built vehicle model meets its performance metrics. We include quantitative performance metrics in our Autonomie modeling to ensure that the vehicle models can meet real-world performance metrics that consumers observe and that are important for vehicle utility and customer satisfaction. The four performance metrics that we use in the Autonomie modeling for light duty vehicles are low-speed acceleration (the time required to accelerate from 0–60 mph), high-speed passing acceleration (the time required to accelerate from 50–80 mph), gradeability (the ability of the vehicle to maintain constant 65 mph speed on a six percent upgrade), and towing capacity for light duty pickup trucks. We have been using these performance metrics for the last several CAFE Model analyses, and vehicle manufacturers have repeatedly agreed that these performance metrics are representative of the metrics considered in the automotive industry.[230] Argonne simulates the vehicle model driving the two-cycle tests (*i.e.,* running its treadmill ''programs'') to ensure that it meets its applicable performance metrics (*e.g.,* our MedSUVPerf does not have to meet the towing capacity performance metric because it is not a pickup truck). For HDPUVs, Autonomie examines sustainable maximum speed at 6 percent grade, start/launch capability on grade, and maximum sustainable grade at highway cruising speed, before examining towing capability to look for the maximum possible vehicle weight over 40 mph in gradeability. This process ensures that the vehicle can satisfy the gradeability requirement (over 40 mph) with additional payload mass to the curb weight. These metrics are based on commonly used metrics in the automotive industry, including SAE J2807 tow requirements.[231] Additional details about how we size light duty and HDPUV powertrains in Autonomie to meet defined performance metrics can be found in the CAFE Analysis Autonomie Documentation.

If the vehicle model does not initially meet one of the performance metrics, then Autonomie's powertrain sizing algorithm increases the vehicle's engine power. The increase in power is achieved by increasing engine displacement (which is the measure of the volume of all cylinders in an engine), which might involve an increase in the number of engine cylinders, which may lead to an increase in the engine weight. This iterative process then determines if the baseline vehicle with increased engine power and corresponding updated engine weight meets the required performance metrics. The powertrain sizing algorithm stops once all the baseline vehicle's performance requirements are met.

Some technologies require extra steps for performance optimization before the vehicle models are ready for simulation. Specifically, the sizing and optimization process is more complex for the electrified vehicles, which includes hybrid electric vehicle (HEVs) and plug-in hybrid electric vehicles (PHEVs), compared to vehicles with only ICEs, as discussed further in the TSD. As an example, a PHEV powertrain that can travel a certain number of miles on its battery energy alone (referred to as all-electric range (AER), or as performing in electric-only mode) is also sized to ensure that it can meet the performance requirements of the SAE standardized drive cycles mentioned above in electric-only mode.

Every time a vehicle model in Autonomie adopts a new technology, the vehicle weight is updated to reflect the weight of the new technology. For some technologies, the direct weight change is easy to assess. For example, when a vehicle is updated to a higher geared transmission, the weight of the original transmission is replaced with the corresponding transmission weight (*e.g.,* the weight of a vehicle moving from a 6-speed automatic (AT6) to an 8-speed automatic (AT8) transmission is updated based on the 8-speed transmission weight). For other technologies, like engine technologies, calculating the updated vehicle weight is more complex. As discussed earlier, modeling a change in engine technology involves both the new technology adoption and a change in power (because the reduction in vehicle weight leads to lower engine loads, and a resized engine). When a vehicle adopts new engine technology, the associated weight change to the vehicle is accounted for based on a regression analysis of engine weight versus power.[232]

In addition to using performance metrics that are commonly used by automotive manufacturers, we instruct Autonomie to mimic real-world manufacturer decisions by only resizing engines at specific intervals in the analysis and in specific ways. When a vehicle manufacturer is making decisions about how to change a vehicle model to add fuel economy-improving technology, the manufacturer could entirely ''redesign'' the vehicle, or the manufacturer could ''refresh'' the vehicle with relatively more minor technology changes. We discuss how our modeling captures vehicle refreshes and redesigns in more detail below, but the details are easier to understand if we start by discussing some straightforward yet important concepts. First, most changes to a vehicle's engine happen when the vehicle is redesigned and not refreshed, as incorporating a new engine in a vehicle is a 10- to 15-year endeavor at a cost of $750 million to $1 billion.[233] But, manufacturers will use that same basic engine, with only minor changes, across multiple vehicle models. We

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[230] *See, e.g.,* NHTSA–2021–0053–1492, at 134 (''Vehicle design parameters are never static. With each new generation of a vehicle, manufacturers seek to improve vehicle utility, performance, and other characteristics based on research of customer expectations and desires, and to add innovative features that improve the customer experience. The Agencies have historically sought to maintain the performance characteristics of vehicles modeled with fuel economy-improving technologies. Auto Innovators encourages the Agencies to maintain a performance-neutral approach to the analysis, to the extent possible. Auto Innovators appreciates that the Agencies continue to consider highspeed acceleration, gradeability, towing, range, traction, and interior room (including headroom) in the analysis when sizing powertrains and evaluating pathways for road-load reductions. All of these parameters should be considered separately, not just in combination. (For example, we do not support an approach where various acceleration times are added together to create a single ''performance'' statistic. Manufacturers must provide all types of performance, not just one or two to the detriment of others.)'').

[231] See SAE. 2020. Performance Requirements for Determining Tow-Vehicle Gross Combination Weight Rating and Trailer Weight Rating. SAE J2807, Available at: *https://www.sae.org/standards/content/j2807_202002/.*

[232] See Merriam-Webster, ''regression analysis'' is the use of mathematical and statistical techniques to estimate one variable from another especially by the application of regression coefficients, regression curves, regression equations, or regression lines to empirical data. In this case, we are estimating engine weight by looking at the relationship between engine weight and engine power.

[233] 2015 NAS Report, at 256. It's likely that manufacturers have made improvements in the product lifetime and development cycles for engines since this NAS report and the report that the NAS relied on, but we do not have data on how much. We believe that it is still reasonable to conclude that generating an all new engine or transmission design with little to no carryover from the previous generation would be a notable investment.

model engine ''inheriting'' from one vehicle to another in both the Autonomie modeling and the CAFE Model. During a vehicle ''refresh'', one vehicle may inherit an already redesigned engine from another vehicle that shares the same platform. In the Autonomie modeling, when a new vehicle adopts fuel saving technologies that are inherited, the engine is not resized (*i.e.,* the properties from the reference vehicle are used directly). While this may result in a small change in vehicle performance, manufacturers have repeatedly and consistently told us that the high costs for redesign and the increased manufacturing complexity that would result from resizing engines for small technology changes preclude them from doing so. In addition, when a manufacturer applies MR technology (*i.e.,* makes the vehicle lighter), the vehicle can use a less powerful engine because there is less weight to move. However, Autonomie will only use a resized engine at certain MR application levels, as a representation of how manufacturers update their engine technologies. Again, this is intended to reflect manufacturer's comments that it would be unreasonable and unaffordable to resize powertrains for every unique combination of technologies. We have determined that our rules about performance neutrality and technology inheritance result in a fleet that is essentially performance neutral.

Why is it important to ensure that the vehicle models in our analysis maintain consistent performance levels? The answer involves how we measure the costs and benefits of different levels of fuel economy standards. In our analysis, we want to capture the costs and benefits of vehicle manufacturers applying fuel economy-improving technologies to their vehicles. For example, say a manufacturer that adds a turbocharger to their engine without downsizing the engine, and then directs all of the additional engine work to additional vehicle horsepower instead of vehicle fuel economy improvements. If we modeled increases or decreases in performance because of fuel economy-improving technology, that increase in performance has a monetized benefit attached to it that is not specifically due to our fuel economy standards. By ensuring that our vehicle modeling remains performance neutral, we can better ensure that we are reasonably capturing the costs and benefits due only to potential changes in the fuel economy standards.

For the NPRM, we analyzed the change in low speed acceleration (0–60 mph) time for four scenarios: (1) MY 2022 under the no action scenario (*i.e.,* No-Action Alternative), (2) MY 2022 under the Preferred Alternative, (3) MY 2032 under the no action scenario, and (4) MY 2032 under the Preferred Alternative.[234] Using the MY 2022 analysis fleet sales volumes as weights, we calculated the weighted average 0–60 mph acceleration time for the analysis fleet in each of the four above scenarios. We identified that the analysis fleet under no action standards in MY 2032 had a 0.5002 percent worse 0–60 mph acceleration time than under the Preferred Alternative, indicating there is minimal difference in performance between the alternatives. Although we did not conduct the same analysis for the final rule preferred standard, we are confident that the difference in performance time would be insignificant, similar to the NPRM analysis, because the preferred standard falls between the no action and the proposal.

Autonomie then adopts one single fuel saving technology to the initial vehicle model, keeping everything else the same except for that one technology and the attributes associated with it. Once one technology is assigned to the vehicle model and the new vehicle model meets its performance metrics, the vehicle model is used as an input to the full vehicle simulation. This means that Autonomie simulates driving the optimized vehicle models for each technology class on the test cycles we described above. As an example, the Autonomie modeling could start with 14 initial vehicle models (one for each technology class in the LD and HDPUV analysis). Those 14 initial vehicle models use a 5-speed automatic transmission (AT5).[235] Argonne then builds 14 new vehicle models; the only difference between the 14 new vehicle models and the first set of vehicle models is that the new vehicle models have a 6-speed automatic transmission (AT6). Replacing the AT5 with an AT6 would lead either to an increase or decrease in the total weight of the vehicle because each technology class includes different assumptions about transmission weight. Argonne then ensures that the new vehicle models with the 6-speed automatic transmission meet their performance metrics. Now we have 28 different vehicle models that can be simulated on the two-cycle tests. This process is repeated for each technology option and for each technology class. This results in fourteen separate datasets, each with over 100,000 results, that include information about a vehicle model made of specific fuel economy-improving technology and the fuel economy value that the vehicle model achieved driving its simulated test cycles.

We condense the million-or-so datapoints from Autonomie into three datasets used in the CAFE Model. These three datasets include (1) the fuel economy value that each modeled vehicle achieved while driving the test cycles, for every technology combination in every technology class (converted into ''fuel consumption'', which is the inverse of fuel economy; fuel economy is mpg and fuel consumption is gallons per mile); (2) the fuel economy value for PHEVs driving those test cycles, when those vehicles drive on gasoline-only in order to comply with statutory constraints; and (3) optimized battery costs for each vehicle that adopts some sort of electrified powertrain (this is discussed in more detail below).

Now, how does this information translate into the technology effectiveness data that we use in the CAFE Model? An important feature of this analysis is that the fuel economy improvement from each technology and combinations of technologies should be accurate and relative to a consistent reference point. We use the absolute fuel economy values from the full vehicle simulations only to determine the relative fuel economy improvement from adding a set of technologies to a vehicle, but not to assign an absolute fuel economy value to any vehicle model or configuration. For this analysis, the absolute fuel economy value for each vehicle in the analysis fleet is based on CAFE compliance data. For subsequent technology changes, we apply the incremental fuel economy improvement values from one or more technologies to the analysis fleet vehicle's fuel economy value to determine the absolute fuel economy achieved for applying the technology change. Accordingly, when the CAFE Model is assessing how to cost-effectively add technology to a vehicle in order to improve the vehicle's fuel economy value, the CAFE Model calculates the difference in the fuel economy value from an Autonomie modeled vehicle with less technology and an Autonomie modeled vehicle with more technology. The relative difference between the two Autonomie modeled vehicles' fuel economy values is applied to the actual fuel economy

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[234] The baseline reference for both the No-Action Alternative and the Preferred Alternative is MY 2022 fleet performance.

[235] Note that although both the LD and HDPUV analyses include a 5-speed automatic transmission, the characteristics of those transmissions differ between the two analyses.

value of a vehicle in the CAFE Model's analysis fleet.

Let's return to our Ravine Runner F Series, which has a starting fuel economy value of just over 26 mpg and a starting technology key ''TURBOD; AT10L2; SS12V; ROLL0; AERO5; MR3.'' The equivalent Autonomie vehicle model has a starting fuel economy value of just over 30.8 mpg and is represented by the technology descriptors Midsize_ SUV, Perfo, Micro Hybrid, eng38, AUp, 10, MR3, AERO1, ROLL0. In 2028, the CAFE Model determines that Generic Motors needs to redesign the Ravine Runner F Series to reach Generic Motors' new light truck CAFE standard. The Ravine Runner F Series now has lots of new fuel economy-improving technology—it is a parallel strong HEV with a TURBOE engine, an integrated 8-speed automatic transmission, 30% improvement in ROLL, 20% aerodynamic drag reduction, and 10% lighter glider (*i.e.,* mass reduction). Its new technology key is now P2TRBE, ROLL30, AERO20, MR3. Table III–3 shows how the incremental fuel economy improvement from the Autonomie simulations is applied to the Ravine Runner F Series' starting fuel economy value.

Table III-3: Example Translation from the Autonomie Effectiveness Database to the CAFE Model

Model	Starting Technology Key/Technology Descriptors	MPG	Ending Technology Key/Technology Descriptors	MPG
CAFE Model	TURBOD; AT10L2; SS12V; ROLL0; AERO5; MR3	26.1	P2TRBE, ROLL30, AERO20, MR3	36.3
Autonomie	Midsize_SUV, Perfo, Micro Hybrid, eng38, AUp, 10, MR3, AERO1, ROLL0	30.8	Midsize_SUV, Perfo, Par HEV, eng37, AUp 8, MR3, AERO4, ROLL3	42.9

Note that the fuel economy values we obtain from the Autonomie modeling are based on the city and highway test cycles (*i.e.,* the two-cycle test) described above. This is because we are statutorily required to measure vehicle fuel economy based on the two-cycle test.[236] In 2008, EPA introduced three additional test cycles to bring fuel economy ''label'' values from two-cycle testing in line with the efficiency values consumers were experiencing in the real world, particularly for hybrids. This is known as 5-cycle testing. Generally, the revised 5-cycle testing values have proven to be a good approximation of what consumers will experience while driving, significantly better than the previous two-cycle test values. Although the compliance modeling uses two-cycle fuel economy values, we use the ''on-road'' fuel economy values, which are the ratio of 5-cycle to 2-cycle testing values (*i.e.,* the CAFE compliance values to the ''label'' values)[237] to calculate the value of fuel savings to the consumer in the effects analysis. This is because the 5-cycle test fuel economy values better represent fuel savings that consumers will experience from real-world driving. For more information about these calculations, please see Section 5.3.2 of the CAFE Model Documentation, and our discussion of the effects analysis later in this section.

In sum, we use Autonomie to generate physics-based full vehicle modeling and simulation technology effectiveness estimates. These estimates ensure that our modeling captures differences in technology effectiveness due to (1) vehicle size and performance relative to other vehicles in the analysis fleet; (2) other technologies on the vehicle and/or being added to the vehicle at the same time; and (3) and how the vehicle is driven. This modeling approach also comports with the NAS 2015 recommendation to use full vehicle modeling supported by the application of lumped improvements at the sub-model level.[238] The approach allows the isolation of technology effects in the analysis supporting an accurate assessment.

In our analysis, ''technology effectiveness values'' are the relative difference between the fuel economy value for one Autonomie vehicle model driving the two-cycle tests, and a second Autonomie vehicle model that uses new technology driving the two-cycle tests. We add the difference between two Autonomie-generated fuel economy values to a vehicle in the Market Data Input File's CAFE compliance fuel economy value. We then calculate the costs and benefits of different levels of fuel economy standards using the incremental improvement required to bring an analysis fleet vehicle model's fuel economy value to a level that contributes to a manufacturer's fleet meeting its CAFE standard.

In the next section, Technology Costs, we describe the process of generating costs for the Technologies Input File.

4. Technology Costs

We estimate present and future costs for fuel-saving technologies based on a vehicle's technology class and engine size. In the Technologies Input File, there is a separate tab for each technology class that includes unique costs for that class (depending on the technology), and a separate tab for each engine size that also contains unique engine costs for each engine size. These

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[236] 49 U.S.C. 32904(c) (EPA ''shall measure fuel economy for each model and calculate average fuel economy for a manufacturer under testing and calculation procedures prescribed by the Administrator. However, except under section 32908 of this title, the Administrator shall use the same procedures for passenger automobiles the Administrator used for model year 1975 (weighted 55 percent urban cycle and 45 percent highway cycle), or procedures that give comparable results.'').

[237] We apply a certain percent difference between the 2-cycle test value and 5-cycle test value to represent the gap in compliance fuel economy and real-world fuel economy.

[238] 2015 NAS report, at 292.

technology cost estimates are based on three main inputs. First, we estimate direct manufacturing costs (DMCs), or the component and labor costs of producing and assembling a vehicle's physical parts and systems. DMCs generally do not include the indirect costs of tools, capital equipment, financing costs, engineering, sales, administrative support or return on investment. We account for these indirect costs via a scalar markup of DMCs, which is termed the RPE. Finally, costs for technologies may change over time as industry streamlines design and manufacturing processes. We estimate potential cost improvements from improvements in the manufacturing process with learning effects (LEs). The retail cost of technology in any future year is estimated to be equal to the product of the DMC, RPE, and LE. Considering the retail cost of equipment, instead of merely DMCs, is important to account for the real-world price effects of a technology, as well as market realities. Each of these technology cost components is described briefly below and in the following individual technology sections, and in detail in Chapters 2 and 3 of the TSD.

DMCs are the component and assembly costs of the physical parts and systems that make up a complete vehicle. We estimate DMCs for individual technologies in several ways. Broadly, we rely in large part on costs estimated by the NHTSA-sponsored 2015 NAS study on the Cost, Effectiveness, and Deployment of Fuel Economy Technologies for LDVs and other NAS studies on fuel economy technologies; BatPaC, a publicly available battery pack modeling software developed and maintained by Argonne, NHTSA-sponsored teardown studies, and our own analysis of how much advanced MR technology (*i.e.,* carbon fiber) is available for vehicles now and in the future; confidential business information (CBI); and off-cycle and AC efficiency costs from the EPA Proposed Determination TSD.[239] While DMCs for fuel-saving technologies reflect the best estimates available today, technology cost estimates will likely change in the future as technologies are deployed and as production is expanded. For emerging technologies, we use the best information available at the time of the analysis and will continue to update cost assumptions for any future analysis.

Our direct costs include materials, labor, and variable energy costs required to produce and assemble the vehicle; however, direct costs do not include production overhead, corporate overhead, selling costs, or dealer costs, which all contribute to the price consumers ultimately pay for the vehicle. These components of retail prices are illustrated in Table III–4 below.

Table III-4: Retail Price Components

Direct Costs	
Manufacturing Cost	Cost of materials, labor, and variable energy needed for production
Indirect Costs	
Production Overhead	
Warranty	Cost of providing product warranty
Research and Development	Cost of developing and engineering the product
Depreciation and amortization	Depreciation and amortization of manufacturing facilities and equipment
Maintenance, repair, operations	Cost of maintaining and operating manufacturing facilities and equipment
Corporate Overhead	
General and Administrative	Salaries of nonmanufacturing labor, operations of corporate offices, etc.
Retirement	Cost of pensions for nonmanufacturing labor
Health Care	Cost of health care for nonmanufacturing labor
Selling Costs	
Transportation	Cost of transporting manufactured goods
Marketing	Manufacturer costs of advertising manufactured goods
Dealer Costs	
Dealer selling expense	Dealer selling and advertising expense
Dealer profit	Net Income to dealers from sales of new vehicles
Net income	Net income to manufacturers from production and sales of new vehicles

To estimate total consumer costs (*i.e.,* both direct and indirect costs), we multiply a technology's DMCs by an indirect cost factor to represent the average price for fuel-saving technologies at retail. The factor that we use is the RPE, and it is the most commonly used to estimate indirect costs of producing a motor vehicle. The RPE markup factor is based on an examination of historical financial data contained in 10–K reports filed by manufacturers with the Securities and Exchange Commission (SEC). It represents the ratio between the retail

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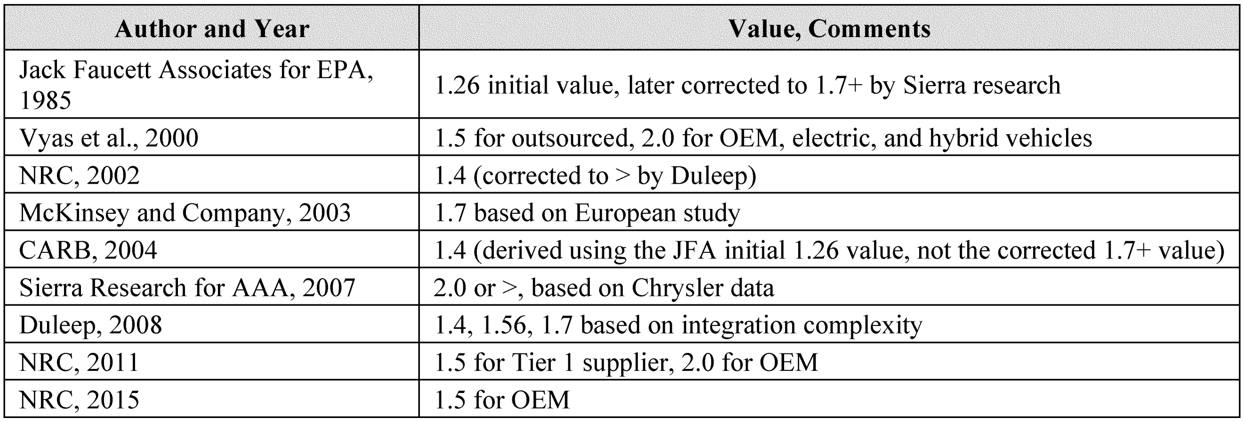
[239] EPA. 2016. Proposed Determination on the Appropriateness of the Model Year 2022–2025 Light-Duty Vehicle Greenhouse Gas Emissions Standards under the Midterm Evaluation: Technical Support Document. Assessment and Standards Division, Office of Transportation and Air Quality. Available at: *https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100Q3L4.pdf.* (Accessed: Feb. 27, 2024).

price of motor vehicles and the direct costs of all activities that manufacturers engage in.

For more than three decades, the retail price of motor vehicles has been, on average, roughly 50 percent above the direct cost expenditures of manufacturers.[240] This ratio has been remarkably consistent, averaging roughly 1.5 with minor variations from year to year over this period. At no point has the RPE markup based on 10–K reports exceeded 1.6 or fallen below 1.4.[241] During this time frame, the average annual increase in real direct costs was 2.5 percent, and the average annual increase in real indirect costs was also 2.5 percent. The RPE averages 1.5 across the lifetime of technologies of all ages, with a lower average in earlier years of a technology's life, and, because of LEs on direct costs, a higher average in later years. Many automotive industry stakeholders have either endorsed the 1.5 markup,[242] or have estimated alternative RPE values. As seen in Table III–5 all estimates range between 1.4 and 2.0, and most are in the 1.4 to 1.7 range.

Table III-5: Alternate Estimates of the RPE[243]



Author and Year	Value, Comments
Jack Faucett Associates for EPA, 1985	1.26 initial value, later corrected to 1.7+ by Sierra research
Vyas et al., 2000	1.5 for outsourced, 2.0 for OEM, electric, and hybrid vehicles
NRC, 2002	1.4 (corrected to > by Duleep)
McKinsey and Company, 2003	1.7 based on European study
CARB, 2004	1.4 (derived using the JFA initial 1.26 value, not the corrected 1.7+ value)
Sierra Research for AAA, 2007	2.0 or >, based on Chrysler data
Duleep, 2008	1.4, 1.56, 1.7 based on integration complexity
NRC, 2011	1.5 for Tier 1 supplier, 2.0 for OEM
NRC, 2015	1.5 for OEM

An RPE of 1.5 does not imply that manufacturers automatically mark up each vehicle by exactly 50 percent. Rather, it means that, over time, the competitive marketplace has resulted in pricing structures that average out to this relationship across the entire industry. Prices for any individual model may be marked up at a higher or lower rate depending on market demand. The consumer who buys a popular vehicle may, in effect, subsidize the installation of a new technology in a less marketable vehicle. But, on average, over time and across the vehicle fleet, the retail price paid by consumers has risen by about $1.50 for each dollar of direct costs incurred by manufacturers. Based on our own evaluation and the widespread use and acceptance of the RPE by automotive industry stakeholders, we have determined that the RPE provides a reasonable indirect cost markup for use in our analysis. A detailed discussion of indirect cost methods and the basis for our use of the RPE to reflect these costs, rather than other indirect cost markup methods, is available in the FRIA for the 2020 final rule.[244]

Finally, manufacturers make improvements to production processes over time, which often result in lower costs. "Cost learning" reflects the effect of experience and volume on the cost of production, which generally results in better utilization of resources, leading to higher and more efficient production. As manufacturers gain experience through production, they refine production techniques, raw material and component sources, and assembly methods to maximize efficiency and reduce production costs.

We estimated cost learning by considering methods established by T.P. Wright and later expanded upon by J.R. Crawford. Wright, examining aircraft production, found that every doubling of cumulative production of airplanes resulted in decreasing labor hours at a fixed percentage. This fixed percentage is commonly referred to as the progress rate or progress ratio, where a lower rate implies faster learning as cumulative production increases. J.R. Crawford expanded upon Wright's learning curve theory to develop a single unit cost model, which estimates the cost of the nth unit produced given the following information is known: (1) cost to produce the first unit; (2) cumulative

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[240] Rogozhin, A. et al. 2009. Automobile Industry Retail Price Equivalent and Indirect Cost Multipliers. EPA. RTI Project Number 0211577.002.004. Triangle Park, N.C.; Spinney, B.C. et al. 1999. Advanced Air Bag Systems Cost, Weight, and Lead Time Analysis Summary Report. Contract NO. DTNH22–96–0–12003. Task Orders—001, 003, and 005. Washington, DC.

[241] Based on data from 1972–1997 and 2007. Data were not available for intervening years but results for 2007 seem to indicate no significant change in the historical trend.

[242] Chris Nevers, Vice President, Energy & Environment, Alliance of Automobile Manufacturers via *Regulations.gov*. Docket No. EPA–HQ–OAR–2018–0283–6186, at 143.

[243] Duleep, K.G. 2008. Analysis of Technology Cost and Retail Price. Presentation to Committee on Assessment of Technologies for Improving LDV Fuel Economy. January 25, 2008, Detroit, MI.; Jack Faucett Associates. 1985. Update of EPA's Motor Vehicle Emission Control Equipment Retail Price Equivalent (RPE) Calculation Formula. September 4, 1985. Chevy Chase, MD.; McKinsey & Company. 2003. Preface to the Auto Sector Cases. New Horizons—Multinational Company Investment in Developing Economies. San Francisco, CA.; NRC. 2002. Effectiveness and Impact of Corporate Average Fuel Economy Standards. The National Academies Press. Washington, DC Available at: *https://nap.nationalacademies.org/catalog/10172/effectiveness-and-impact-of-corporate-average-fuel-economy-cafe-standards.* (Accessed: Apr. 5, 2024).; NRC. 2011. Assessment of Fuel Economy Technologies for LDVs. The National Academies Press. Washington, DC; NRC. 2015. Cost, Effectiveness, and Deployment of Fuel Economy Technologies in LDVs. The National Academies Press. Washington, DC; Sierra Research, Inc. 2007. Study of Industry-Average Mark-Up Factors used to Estimate Changes in Retail Price Equivalent (RPE) for Automotive Fuel Economy and Emissions Control Systems. Sierra Research Inc. Sacramento, CA; Vyas, A. et al. 2000. Comparison of Indirect Cost Multipliers for Vehicle Manufacturing. Center for Transportation Research. ANL. Argonne, Ill.

[244] NHTSA and EPA. 2020. FRIA: The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Year 2021–2026 Passenger Cars and Light Trucks. Available at: *https://www.nhtsa.gov/sites/nhtsa.gov/files/documents/final_safe_fria_web_version_200701.pdf.* (Accessed: Mar. 29, 2024).

production of n units; and (3) the progress ratio.

Consistent with Wright's learning curve, most technologies in the CAFE Model use the basic approach by Wright, where we estimate technology cost reductions by applying a fixed percentage to the projected cumulative production of a given fuel economy technology in a given MY.[245] We estimate the cost to produce the first unit of any given technology by identifying the DMC for a technology in a specific MY. As discussed above and in detail below and in Chapter 3 of the TSD, our technology DMCs come from studies, teardown reports, other publicly available data, and feedback from manufacturers and suppliers. Because different studies or cost estimates are based on costs in specific MYs, we identify the "base" MYs for each technology where the learning factor is equal to 1.00. Then, we apply a progress ratio to back-calculate the cost of the first unit produced. The majority of technologies in the CAFE Model use a progress ratio (*i.e.,* the slope of the learning curve, or the rate at which cost reductions occur with respect to cumulative production) of approximately 0.89, which is derived from average progress ratios researched in studies funded and/or identified by NHTSA and EPA.[246] Many fuel economy technologies that have existed in vehicles for some time will have a gradual sloping learning curve implying that cost reductions from learning is moderate and eventually becomes less steep toward MY2050. Conversely, newer technologies have an initial steep learning curve where cost reduction occurs at a high rate. Mature technologies will generally have a flatter curve and may not incur much cost reduction, if at all, from learning. For an illustration showing various slopes of learning curves, see TSD Chapter 2.4.4.

We assign groups of similar technologies or technologies of similar complexity to each learning curve. While the grouped technologies differ in operating characteristics and design, we chose to group them based on market availability, complexity of technology integration, and production volume of the technologies that can be implemented by manufacturers and suppliers. In general, we consider most base and basic engine and transmission technologies to be mature technologies that will not experience any additional improvements in design or manufacturing. Other basic engine technologies, like VVL, SGDI, and DEAC, do decrease in costs through around MY 2036, because those were introduced into the market more recently. All advanced engine technologies follow the same general pattern of a gradual reduction in costs until MY 2036, when they plateau and remain flat. We expect the cost to decrease as production volumes increase, manufacturing processes are improved, and economies of scale are achieved. We also assigned advanced engine technologies that are based on a singular preceding technology to the same learning curve as that preceding technology. Similarly, the more advanced transmission technologies experience a gradual reduction in costs through MY 2031, when they plateau and remain flat. Lastly, we estimate that the learning curves for road load technologies, with the exception of the most advanced MR level (which decreases at a fairly steep rate through MY 2040, as discussed further below and in Chapter 3.4 of the TSD), will decrease through MY 2036 and then remain flat.

We use the same cost learning rates for both LD and HDPUV technologies. This approach was used in the HDPUV analysis in the Phase 2 HD joint rule with EPA,[247] and we believe that this is an appropriate assumption to continue to use for this analysis. While the powertrains in HDPUVs do have a higher power output than LD powertrains, the designs and technology used will be very similar. Although most HDPUV components will have higher operating loads and provide different effectiveness values than LD components, the overall designs are similar between the technologies. The individual technology design and effectiveness differences between LD and HDPUV technologies are discussed below and in Chapter 3 of the TSD.

For technologies that have been in production for many years, like some engine and transmission technologies, this approach produces reasonable estimates that we can compare against other studies and publicly available data. Generating the learning curve for battery packs for BEVs in future MYs is significantly more complicated, and we discuss how we generated those learning curves in Section III.D and in detail in Chapter 3.3 of the TSD. Our battery pack learning curves recognize that there are many factors that could potentially lower battery pack costs over time outside of the cost reductions due to improvements in manufacturing processes due to knowledge gained through experience in production.

Table III–6 shows how some of the technologies on the MY 2022 Ravine Runner Type F decrease in cost over several years. Note that these costs are specifically applicable to the MedSUVPerf class, and other technology classes may have different costs for the same technologies. These costs are pulled directly from the Technology Costs Input File, meaning that they include the DMC, RPE, and learning.

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[245] We use statically projected cumulative volume production estimates beause the CAFE Model does not support dynamic projections of cumulative volume at this time.

[246] Simons, J.F. 2017. Cost and Weight Added By the Federal Motor Vehicle Safety Standards for MY 1968–2012 Passenger Cars and LTVs. Report No. DOT HS 812 354. NHTSA. Washington DC at 30–33.; Argote, L. et al. 1997. The Acquisition and Depreciation of Knowledge in a Manufacturing Organization—Turnover and Plant Productivity. Working Paper. Graduate School of Industrial Administration, Carnegie Mellon University; Benkard, C.L. 2000. Learning and Forgetting—The Dynamics of Aircraft Production. *The American Economic Review.* Vol. 90(4): at 1034–54; Epple, D. et al. 1991. Organizational Learning Curves—A Method for Investigating Intra-Plant Transfer of Knowledge Acquired through Learning by Doing. *Organization Science.* Vol. *2*(1): at 58–70; Epple, D. et al. 1996. An Empirical Investigation of the Microstructure of Knowledge Acquisition and Transfer through Learning by Doing. *Operations Research.* Vol. 44(1): at 77–86; Levitt, S.D. et al. 2013. Toward an Understanding of Learning by Doing—Evidence from an Automobile Assembly Plant. *Journal of Political Economy.* Vol. 121(4): at 643–81.

[247] See MDHD Phase 2 FRIA at 2–56, noting that gasoline engines used in Class 2b and Class 3 pickup trucks and vans include the engines offered in a manufacturer's light-duty truck counterparts, as well as engines specific to the Class 2b and Class 3 segment, and describing that the the technology definitions are based on those described in the LD analysis, but the effectiveness values are different.

Table III-6: Absolute Costs for Example Ravine Runner Type F Technologies

Technology (MedSUVPerf)	2022	2027	2032
TURBOD (8C2B)	$8,924.90	$8,877.31	$8,851.36
AT10L2	$2,848.19	$2,806.64	$2,790.92
SS12V	$215.47	$191.01	$180.28
AERO5	$55.30	$50.91	$48.70

5. Simulating Existing Incentives, Other Government Programs, and Manufacturer ZEV Deployment Plans

Similar to the regulations that we are enacting, other government actions have the ability to influence the technology manufacturers apply to their vehicles. For the purposes of this analysis, we incorporate manufacturers' expected response to two other government actions into our analysis: state ZEV requirements and Federal tax credits. We also include ZEV deployment that manufacturers have committed to execute even though it goes beyond any government's legal requirements.

a. Simulating ZEV Deployment Unrelated to NHTSA's Standards

The California Air Resources Board (CARB) has developed various programs to control emissions of criteria pollutants and GHGs from vehicles sold in California. CARB does so in accordance with the federal CAA; CAA section 209(a) generally preempts states from adopting emission control standards for new motor vehicles; [248] however, Congress created an exemption program in CAA section 209(b) that allows the State of California to seek a waiver of preemption related to adopting or enforcing motor vehicle emissions standards.[249] EPA must grant the waiver unless the Agency makes one of three statutory findings.[250] Under CAA section 177, other States can adopt and enforce standards identical to those approved under California's Section 209(b) waiver and other specified criteria in section 177 are met.[251] States that do so are sometimes referred to as section 177 states, in reference to section 177 of the CAA. Since 1990, CARB has included a version of a Zero-Emission Vehicle (ZEV) program as part of its package of standards that control smog-causing pollutants and GHG emissions from passenger vehicles sold in California,[252] and several states have adopted those ZEV program requirements. This section focuses on the way we modeled manufacturers' expected compliance with these ZEV program requirements as well as additional electric vehicle deployment that manufacturers have indicated they will undertake. See Section IV.B.1 for a discussion of the role of these electric vehicles in the reference baseline and associated comments and responses.

There are currently two operative ZEV regulations that we consider in our analysis: ACC I (LD ZEV requirements through MY 2025) [253] and Advanced Clean Trucks (ACT) (requirements for trucks in Classes 2b through 8, from MYs 2024–2035).[254] California has adopted a third ZEV regulation, ACC II (LD ZEV requirements for MYs 2026–2035).[255] EPA is evaluating a petition for a waiver of Clean Air Act preemption for ACC II,[256] but has not granted it. While ACC II is currently unenforceable while the waiver request is under consideration by EPA—in contrast to ACC I and ACT, which have already received waiver approvals—manufacturers have indicated that they intend to deploy additional electric vehicles consistent with (or beyond) what ACC II would require for compliance if a waiver were to be granted. We have therefore modeled compliance with ACC II as a proxy for these additional electric vehicles that manufacturers have committed to deploying in the reference baseline or No-Action Alternative. As discussed further below, we also developed a sensitivity case and an alternative baseline that included, respectively, some or none of the electric vehicles that would be expected to enter the fleet under ACC I, ACT, and manufacturer deployment commitments consistent with ACC II in order to ensure that our standards satisfy the statutory factors regardless of which baseline turns out to be the most accurate.

In the NPRM, we stated that we are confident that manufacturers will comply with the ZEV programs because they have previously complied with state ZEV programs, and they have made announcements of new ZEVs demonstrating an intent to comply with the requirements going forward. The American Fuel & Petrochemical Manufacturers (AFPM) objected to the use of the word ''confident'' given their concerns about manufacturers' ability to comply with ZEV standards.[257] Valero and Kia commented that CARB historically has eased compliance for manufacturers by allowing for compliance via changing compliance dates, stringencies, and ZEV definitions.[258] Valero also commented that our inclusion of ACT was premature given its 2024 start date and stated their doubts about its technological feasibility.[259]

We focus on including the provisions that CARB and other states currently have in place in their regulations and that have received a Clean Air Act

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[248] 42 U.S.C. 7543(a).

[249] 42 U.S.C. 7543(b).

[250] See 87 FR 14332 (March 14, 2022). (''The CAA section 209(b) waiver is limited ''to any State which has adopted standards . . . for the control of emissions from new motor vehicles or new motor vehicle engines prior to March 30, 1966,'' and California is the only State that had standards in place before that date.''). NHTSA notes that EPA has not yet granted a waiver of preemption for the ACC II program, and NHTSA does not prejudge EPA's decisionmaking. Nonetheless, NHTSA believes it is reasonable to consider ZEV sales volumes that manufacturers will produce consistent with what would be required to comply with ACC II as part of our consideration of actions that occur in the absence of fuel economy standards, because manufacturers have indicated that they intend to deploy those vehicles regardless of whether a waiver is granted.

[251] 42 U.S.C. 7507.

[252] CARB. Zero-Emission Vehicle Program. Available at: *https://ww2.arb.ca.gov/our-work/programs/zero-emission-vehicle-program/about.* (Accessed: Mar. 19, 2024).

[253] 13 CCR 1962.2.

[254] CARB. 2019. Final Regulation Order: Advanced Clean Trucks Regulation. Available at: *https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2019/act2019/fro2.pdf.* (Accessed: Mar. 29, 2024).

[255] CARB. Advanced Clean Cars II. *https://ww2.arb.ca.gov/our-work/programs/advanced-clean-cars-program/advanced-clean-cars-ii.*

[256] 88 FR 88908 (Dec. 26, 2023), Notice of opportunity for public hearing and comment on California Air Resources Board ACCII Waiver Request.

[257] AFPM, Docket No. NHTSA–2023–0022–61911–A2, at 34.

[258] Valero, Docket No. NHTSA–2023–0022–58547–A4, at 2; Valero, Docket No. NHTSA–2023–0022–58547–A5, at 2. Kia, Docket No. NHTSA–2023–0022–58542–A1, at 4–5.

[259] Valero, Docket No. NHTSA–2023–0022–58547–A5, at 4.

preemption waiver from EPA, and we have taken this into account by having incorporated changing standards and compliance landscapes in our past and current rulemakings. Valero further cited risks of ZEV programs such as varying compliance challenges across OEMs, consumer preferences, and affordability concerns, as well as general uncertainty in predicting future ZEV sales.[260] NHTSA observes that companies have historically complied with California waivers and notes that even though industry entities such as Valero have previously made such comments about ZEV programs, historically, manufacturers have complied. Further, NHTSA notes that manufacturers have indicated that they intend to deploy electric vehicles consistent with the requirements of not just ACC I and ACT, but also ACC II. In this analysis, NHTSA has not assumed that the ACC II waiver will be granted. However, in the reference baseline, NHTSA has included electric vehicle deployment consistent with stated manufacturer plans to deploy such vehicles—and that level would result in full compliance with the ACC II program.[261] Furthermore, many of the ZEVs that can earn credits from CARB are already present in the 2022 analysis fleet, leading the modeled MY 2022 analysis fleet to achieve 100% compliance with that years' ACC I requirement in MY 2022 (per CARB, the total ending year credit balances significantly exceed the annual credit requirements).[262] NHTSA models manufacturers' compliance with ACC I and ACT and the additional electric vehicle deployment that manufacturers have announced they intend to execute because accounting for technology improvements that manufacturers would make even in the absence of CAFE standards allows NHTSA to gain a more accurate understanding of the effects of the final rule. Importantly, as noted above, NHTSA also developed an alternative baseline, the No ZEV alternative baseline, to test whether the standards remain consistent with the statutory factors regardless of the level of electrification that occurs in the reference baseline. NHTSA also modeled the HDPUV program assuming the ACT program was not included in the reference baseline, even though EPCA/EISA contains no limitations on the consideration of alternative fueled vehicles in that program.

The Zero Emission Transportation Association commented that NHTSA should include CARB's Advanced Clean Fleets (ACF) regulation as part of its modeling. We do not include the Advanced Clean Fleets regulation in our modeling at this time, due to the small number of HDPUV Class 2b/3 vehicles that would be affected by this regulation in the rulemaking time frame,[263] and due to the analytical complexity of modeling this small amount of vehicles. We will continue to monitor this program to determine whether it should be featured in future analyses.

This is the fourth analysis where we have modeled compliance with the ACC program (and now the ACT program) requirements in the CAFE Model. In the MY 2024–2026 final rule, we received feedback from commenters agreeing or disagreeing with the modeling inclusion of the ZEV programs at all, however, the only past substantive comments on the ZEV program modeling methodology have been requesting the inclusion of more states that signed on to adopt California's standards in our analysis. As noted below, the inclusion or exclusion of states in the analysis depends on which states have signed on to the programs at the time of our analysis. While we are aware of legal challenges to some states' adoption of the ZEV programs, it is beyond the scope of this rulemaking to evaluate the likelihood of success of those challenges. For purposes of our analysis, what is important is predicting, using a reasonable assessment, how the fleet will evolve in the future. The following discussion provides updates to our modeling methodology for the ZEV programs in the analysis.

The ACC I and ACT programs require that increasing levels of manufacturers' sales in California and section 177 states in each MY be ZEVs, specifically BEVs, PHEVs, FCEVs.[264] BEVs, PHEVs, and FCEVs each contribute a ''value'' towards a manufacturer's annual ZEV requirement, which is a product of the manufacturer's production volume sold in a ZEV state, multiplied by a ''percentage requirement.'' The percentage requirements increase in each year so that a greater portion of a manufacturer's fleet sold in ZEV states in a particular MY must be ZEVs. For example, a manufacturer selling 100,000 vehicles in California and 10,000 vehicles in Connecticut (both states that have ZEV programs) in MY 2025 must ensure that 22,000 ZEV credits are earned by California vehicles and 2,200 ZEV credits are earned by Connecticut vehicles. In MYs 2026 through 2030 of the ACC II program (if granted a waiver) would allow manufacturers to apply a capped amount of credits to the percentage requirement. In response to various commenters mentioning the pooled credits route, we added this option to our modeling, slightly scaling down the percent requirement assumed to be met by ZEV sales; this corresponds to the maximum pooled credits that would be allowed by CARB under ACC II, if granted a waiver.

At the time of our analysis, seventeen states in addition to California have either formally signed on to the ACC I or ACC II standards or are in the process of adopting them.[265] Although a few states are adopting these requirements in future MYs, for the ease of modeling we include in the unified ACC II group every state that has regulations in place to adopt or is already in the process of adopting the requirements by the time of our analysis at the start of December 2023. A variety of commenters expressed concern with our NPRM approach of considering all the states as a group that adopted the programs in all the model years that CARB outlined. Hyundai noted in their comments that Nevada, Minnesota, and Virginia are ''unlikely to adopt ACC II.'' Commenters such as the AFPM and Nissan stated that several states have adopted only some model years of ACC II. NHTSA notes that its analysis does not assume legal enforcement of ACC II because it has not been granted a preemption waiver, but that manufacturers have nonetheless indicated they intend to deploy electric vehicles during these model years at levels that would be consistent with ACC II in both California and other states. However, to be appropriately conservative, NHTSA has updated its approach to reflect the

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[260] Valero, Docket No. NHTSA–2023–0022–58547–A5, at 5–6.

[261] For example, Stellantis has publicly committed to deployment levels consistent with California's electrification targets. See, *https://www.gov.ca.gov/2024/03/19/stellantis-partners-with-california-on-clean-car-standards/*.

[262] CARB. Annual ZEV Credits Disclosure Dashboard. Available at: *https://ww2.arb.ca.gov/applications/annual-zev-credits-disclosure-dashboard*. (Accessed Mar. 28, 2024).

[263] CARB. Advanced Clean Fleets Regulation Summary. Available at: *https://ww2.arb.ca.gov/resources/fact-sheets/advanced-clean-fleets-regulation-summary*. (Accessed Mar. 28, 2024).

[264] CARB. 2022. Final Regulation Order: Amendments to Section 1962.2, Title 13, California Code of Regulations. Available at: *https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2022/accii/acciifro1962.2.pdf*. (Accessed: Mar. 29, 2024).

[265] California, Colorado, Connecticut, Delaware, Maine, Maryland, Massachusetts, Minnesota, Nevada, New York, New Jersey, New Mexico, Oregon, Rhode Island, Vermont, Virginia, and Washington. See California Air Resource Board. States that have Adopted California's Vehicle Standards under Section 177 of the Federal Clean Air Act. Available at: *https://ww2.arb.ca.gov/our-work/programs/advanced-clean-cars-program/states-have-adopted-californias-vehicle-regulations* (Accessed: Mar. 26, 2024).

variety in model years to which states have committed and in response to comments, we now include different state sales share groups in our modeling. Splitting these groups based on model years in which they have indicated their participation also allows us to distinguish between assumed future ACC I compliance and the deployment that manufacturers have indicated they are intending to execute that would be consistent with ACC II. The seventeen states included in our light-duty ZEV analysis have adopted ACC I and/or ACC II in at least one model year.

Some commenters such as the Center for Environmental Accountability and Nissan stated that many of the states included in our ZEV modeling had not actually adopted the ZEV programs.[266] NHTSA disagrees; we include all states that have regulations in place to adopt or are already in the process of adopting ACC I, ACC II, or ACT, based on information available at the time of the analysis.[267] Our final ZEV state assumptions are also consistent with those tracked by CARB on their website at the time of writing.[268] This included adding states to our analysis that were not present in the NPRM ZEV modeling. Commenters such as ACEEE and the American Lung Association requested that we make these updates to the ZEV states list.[269] We added the state of Colorado into our analysis, based on new information and their comment indicating their commitment to all three ZEV programs.[270] Similarly, eleven states including California have formally adopted the ACT standards at the time of analysis. As this group is smaller and has somewhat less variety in start dates than the ACC I/ACC II states, we model ACT state shares without breaking out specific model year start dates.[271]

It is also important to note in the context of all the above comments on ZEV adoption that NHTSA developed an alternative baseline, the No ZEV alternative baseline, in order to evaluate whether the standards are consistent with the statutory factors regardless of the amount of electrification that occurs in the absence of NHTSA's standards during the standard setting years. NHTSA further evaluated sensitivity cases, that one could certainly consider as additional alternative baselines, that precluded electric vehicles from being added to the fleet between Model Years 2027–2035; between 2027–2050; and 2022–2050.

It is important to note that not all section 177 states have adopted the ACC II or ACT program components. Furthermore, more states have formally adopted the ACC II program than the ACT program, so the discussion in the following sections will call states that have opted in ''ACC I/ACC II states'' or ''ACT states.'' Separately, many states signed a memorandum of understanding (MOU) in 2020 to indicate their intent to work collaboratively towards a goal of turning 100% of MD and HD vehicles into ZEVs in the future. For the purposes of CAFE analysis, we include only those states that have formally adopted the ACT in our modeling as ''ACT states.'' States that have signed the MOU but not formally adopted the ACT program are referred to as ''MOU states'' and are not included in CAFE modeling. When the term ''ZEV programs'' is used hereafter, it refers to both the ACC II and ACT programs.

Incorporating ACC I and ACT as applicable legal requirements and ACC II as a proxy for additional electric vehicle deployment expected to occur regardless of the NHTSA standards into the model includes converting vehicles that have been identified as potential ZEV candidates into BEVs at the vehicle's ZEV application year so that a manufacturer's fleet meets its required ZEV credit requirements. We focused on BEVs as ZEV conversions, rather than PHEVs or FCEVs, because, as for 2026–2035, manufacturers cannot earn more than 20% of their ZEV credits through PHEV sales. Similarly, PHEVs receive a smaller number of credits than BEVs and FCEVs under ACC I, and those with lower all-electric range values would receive a smaller number of credits under ACC II if it became legally enforceable. We determined that including PHEVs in the ZEV modeling would have introduced unnecessary complication to the modeling and would have provided manufacturers little benefit in the modeled program. In addition, although FCEVs can earn the same number of credits as BEVs, we chose to focus on BEV technology pathways since FCEVs are generally less cost-effective than BEVs and most manufacturers have not been producing them at high volumes. However, any PHEVs and FCEVs already present in the CAFE Model analysis fleets receive ZEV credits in our modeling.

Total credits are calculated by multiplying the credit value each ZEV receives by the vehicle's volume. In the ACC I program, until 2025, each full ZEV can earn up to 4 credits. In the ACC II program, from 2026 onwards, each full ZEV would earn one credit value per vehicle, while partial ZEVs (PHEVs) would earn credits based on their AER, if ACC II became legally enforceable. In the context of this section, ''full ZEVs'' refers to BEVs and FCEVs, as PHEVs can receive a smaller number of credits than other ZEVs, as discussed above. Based on comments from CARB and the Strong PHEV Coalition,[272] we adjusted the number of ZEV credits received by PHEV50s in our analysis to 1 full credit under the ACC II proxy after determining with Argonne that the range of all the PHEVs marked as ''PHEV50s'' in our analysis fleet was sufficient to receive the full ZEV credit. Credit targets in the ACT program (referred to as deficits) are calculated by multiplying sales by percentage requirement and weight class multiplier. Each HDPUV full ZEV in the 2b/3 class earns 0.8 credits and each near-zero emissions vehicle (called PHEVs in the CAFE Model) earns 0.75 credits.[273] We adjusted some of the explanations in this section and the TSD accompanying this rule in response to a comment from CARB requesting that we very clearly distinguish between the number of credits earned between different vehicle types and programs.[274]

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[266] CEA, Docket No. NHTSA–2023–0022–61918–A1, at 9; Nissan, Docket No. NHTSA–2023–0022–60696, at 4.

[267] See ZEV states docket reference folder. NHTSA–2023–0022.

[268] CARB. 2024. States that have Adopted California's Vehicle Regulations. Available at: *https://ww2.arb.ca.gov/our-work/programs/advanced-clean-cars-program/states-have-adopted-californias-vehicle-regulations.* (Accessed: Mar. 26, 2024).

[269] ACEEE, Docket No. NHTSA–2023–0022–60684, at 11; ALA, Docket No, NHTSA–2023–0022–60091, at 3.

[270] RFA et al, Docket No. NHTSA–2023–0022–57625, at 1.

[271] California, Colorado, Connecticut, Maryland, Massachusetts, New Jersey, New Mexico, New York, Oregon, Vermont and Washington. We include Connecticut as their House passed the legislation instructing their Department of Energy and Environmental Protection to adopt ACT. See Electric Trucks Now. 2023. States are Embracing Electric Trucks. Available at: *https://www.electrictrucksnow.com/states.* (Accessed: Mar. 29, 2024); Vermont Biz. 2022. Vermont adopts rules for cleaner cars and trucks. Available at: *https://vermontbiz.com/news/2022/november/24/vermont-adopts-rules-cleaner-cars-and-trucks.* (Accessed: May 31, 2023); North Carolina Environmental Quality. Advanced Clean Trucks: Growing North Carolina's Clean Energy Economy. Available at: *https://deq.nc.gov/about/divisions/air-quality/motor-vehicles-and-air-quality/advanced-clean-trucks* (Accessed: May 31, 2023); Connecticut HB 5039. 2022. An Act Concerning Medium and Heavy-Duty Vehicle Emission Standards. Available at: *https://www.cga.ct.gov/2022/fc/pdf/2022HB-05039-R000465-FC.pdf* (Accessed: May 31, 2023).

[272] Strong PHEV Coalition, Docket No. NHTSA–2023–0022–60193, at 4–5; States and Cities, NHTSA–2023–0022–61904–A2, at 46.

[273] CARB. 2022. Final Regulation Order: Advanced Clean Trucks Regulation. Available at: *https://www.cga.ct.gov/2022/fc/pdf/2022HB-05039-R000465-FC.pdf.* (Accessed: Feb. 27, 2024).

[274] States and Cities, Docket No. NHTSA–2023–0022–61904–A2, at 46.

The CAFE Model is designed to present outcomes at a national scale, so the ZEV programs analysis considers the states as a group as opposed to estimating each state's ZEV credit requirements individually. However, in response to comments discussed above, we adjusted our ZEV modeling to reflect states' varying commitments to the ACC I and ACC II programs in different model years. To capture the appropriate volumes subject to the ACT requirements and that would be deployed consistent with ACC II, we still calculated each manufacturer's total market share in ACC II or ACT states but also expanded the market share inputs to vary across model year according to how many states had opted into the program in each year between 2022 and 2035. We used Polk's National Vehicle Population Profile (NVPP) from January 2022 to calculate these percentages.[275] These data include vehicle characteristics such as powertrain, fuel type, manufacturer, nameplate, and trim level, as well as the state in which each vehicle is sold. At the time of the data snapshot, MY 2021 data from the NVPP contained the most current estimate of new vehicle market shares for most manufacturers, and best represented the registered vehicle population on January 1, 2022. We assumed that this source of new registrations data was the best approximation of new sales given the data options. For MY 2021 vehicles in the latest NVPP, the ACC II State group at its largest makes up approximately 38% of the total LD sales in the United States. The ACT state groups comprise approximately 22% of the new Class 2b and 3 (HDPUV) vehicle market in the U.S.[276] We based the volumes used for the ZEV credit target calculation on each manufacturer's future assumed market share in ACC II and ACT states. We made this assumption after examining three past years of market share data and determining that the geographic distribution of manufacturers' market shares remained fairly constant.

We calculated total credits required for ACT compliance and consistent with ACC II implementation by multiplying the percentages from each program's ZEV requirement schedule by the ACC II or ACT state volumes.[277] For the first set of ACC I requirements covering 2022 (the first modeled year in our analysis) through 2025, the percentage requirements start at 14.5% and ramp up in increments to 22 percent by 2025.[278] For ACC II, the potential percentage requirements start at 35% in MY 2026 and would ramp up to 100% in MY 2035 and subsequent years if it became legally enforceable.[279] For ACT Class 2b–3 Group vehicles (equivalent to HDPUVs in our analysis), the percentage requirements start at 5% in MY 2024 and increase to 55% in MYs 2035 and beyond.[280] We then multiply the resulting national sales volume predictions by manufacturer by each manufacturer's total market share in the ACC II or ACT states to capture the appropriate volumes in the ZEV credits calculation. Credits consistent with ACC II by manufacturer, per year, are determined within the CAFE Model by multiplying the ACC II state volumes by CARB's ZEV credit percentage requirement for each program respectively. In the first five years of the ACC II program (as currently submitted to EPA), MYs 2026–2030, CARB would allow for a pooled credits allowance, capped at a specific percentage per year (which decreases in later years). We accounted for this in the final rule in response to comments by reducing the percent requirement in those years by the maximum pooled credit allowance.

To ensure that the ACT credit requirements are met in the reference baseline and deployment consistent with ACC II is reflected in the reference baseline in each modeling scenario, we add ZEV candidate vehicles to the reference baseline. We flag ZEV candidates in the 'vehicles' worksheet in the Market Data Input File, which is described above and in detail in TSD Chapter 2.5. Although we identify the ZEV candidates in the Market Data Input File, the actual conversion from non-ZEV to ZEV vehicles occurs within the CAFE Model. The CAFE Model converts a vehicle to a ZEV during the specified ZEV application year.

We flag ZEV candidates in two ways: using reference vehicles with ICE powertrains or using PHEVs already in the existing fleet. When using ICE powertrains as reference vehicles, we create a duplicate row (which we refer to as the ZEV candidate row) in the Market Data Input File's Vehicles tab for the ZEV version of the original vehicle, designated with a unique vehicle code. The ZEV candidate row specifies the relevant electrification technology level of the ZEV candidate vehicle (*e.g.,* BEV1, BEV2, and so on), the year that the electrification technology is applied,[281] and zeroes out the candidate vehicle's sales volume. We identify all ICE vehicles with varying levels of technology up to and including strong hybrid electric vehicles (SHEVs) with rows that have 100 sales or more as ZEV candidates. The CAFE Model moves the sales volume from the reference vehicle row to the ZEV candidate row on an as-needed basis, considering the MY's ZEV credit requirements. When using existing PHEVs within the fleet as a starting point for identifying ZEV candidates, we base our determination of ZEV application years for each model based on expectations of manufacturers' future EV offerings. The entire sales volume for that PHEV model row is converted to BEV on the application year. This approach allows for only the needed additional sales volumes to flip to ZEVs, based on the ACC II and ACT targets, and keeps us from overestimating ZEVs in future years. The West Virginia Attorney General's Office commented that ''NHTSA programmed the CAFE model to assume that manufacturers will turn every internal combustion engine vehicle into a ZEV at the 'first redesign opportunity.' ''[282] This comment is a misunderstanding of the ZEV candidate modeling, where the model will shift only the necessary volumes to comply with the ZEV programs into ZEVs. As we stated in the NPRM and repeated above, this approach allows for only the needed additional sales volumes to flip to ZEVs, based on the ACC II and ACT targets, and keeps us from overestimating ZEVs in future years. See TSD Chapter 2.5 for more details on our ZEV program modeling.

We identify LD ZEV candidates by duplicating every row with 100 or more sales that is not a PHEV, BEV, or FCEV. We refer to the original rows as 'reference vehicles.' Although PHEVs are all ZEV candidates, we do not duplicate those rows as we focus the CAFE Model's simulation of the ACC II and ACT programs on BEVs. However, any PHEVs already in the analysis fleet or made by the model will still receive

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[275] National Vehicle Population Profile (NVPP). 2022. Includes content supplied by IHS Markit. Copyright R.L. Polk & Co., 2022. All rights reserved. Available at: *https://repository.duke.edu/catalog/caad9781-5438-4d65-b908-bf7d97a80b3a.* (Accessed: Feb. 27, 2024).

[276] We consulted with Polk and determined that their NVPP data set that included vehicles in the 2b/3 weight class provided the most fulsome dataset at the time of analysis, recognizing that the 2b/3 weight class includes both 2b/3 HD pickups and vans and other classes within 2b/3 segment. While we determined that this dataset was the best option for the analysis, it does not contain all Class 3 pickups and vans sold in the United States.

[277] Note that the ACT credit target calculation includes a vehicle class-specific weight modifier.

[278] 13 CCR 1962.2(b).

[279] 13 CCR 1962.4.

[280] 13 CCR 1963.1(b).

[281] The model turns all ZEV candidates into BEVs in 2023, so sales volumes can be shifted from the reference vehicle row to the ZEV candidate row as necessary.

[282] West Virginia AG et al., Docket No. NHTSA–2023–0022–63056–A1, at 4.

the appropriate ZEV credits. While flagging the ZEV candidates, we identified each one as a BEV1, BEV2, BEV3, and BEV4 (BEV technology types based on range), based partly on their price, market segment, and vehicle features. For instance, we assumed luxury cars would have longer ranges than economy cars. We also assigned AWD/4WD variants of vehicles shorter BEV ranges when appropriate. See TSD Chapter 3.3 for more detailed information on electrification options for this analysis. The CAFE Model assigns credit values per vehicle depending on whether the vehicle is a ZEV in a MY prior to 2026 or after, due to the change in value after the update of the standards from ACC II (as currently submitted to EPA).

We follow a similar process in assigning HDPUV ZEV candidates as in assigning LD ZEV candidates. We duplicate every van row with 100 or more sales and duplicate every pickup truck row with 100 or more sales provided the vehicle model has a WF less than 7,500 and a diesel- or gasoline-based range lower than 500 miles based on their rated fuel efficiency and fuel tank size. This is consistent with our treatment of HDPUV technology applicability rules, which are discussed below in Section III.D and in TSD Chapter 3.3. Note that the model can still apply PHEV technology to HDPUVs because of CAFE standards, and like the LD analysis, any HDPUVs turned into PHEVs will receive credit in the ZEV program. When identifying ZEV candidates, we assign each candidate as either a BEV1 or a BEV2 based on their price, market segment, and other vehicle attributes.

The CAFE Model brings manufacturers into compliance with ACC II (as currently submitted to EPA) and ACT first in the reference baseline, solving for the technology compliance pathway used to meet increasing ZEV standards. Valero commented on the BEV sales shift in the HDPUV analysis being too large for ACT compliance purposes.[283] Our ZEV modeling structure is designed to only convert ZEV candidates if needed for the ACT program requirements. However, the CAFE Model also incorporates many other factors into its technology and CAFE compliance pathways decisions, technology payback, including technology costs and sizing requirements based on vehicle performance. See the TSD Chapter 3.3 and Preamble Section III.D for further discussion of electrification pathways and sales volume results.

In the proposal, we did not include two provisions of the ZEV regulations in our modeling. First, while the ACC II program (as currently submitted to EPA) includes compliance options for providing reduced-price ZEVs to community mobility programs and for selling used ZEVs (known as ''environmental justice vehicle values''), these are focused on a more local level than we could reasonably represent in the CAFE Model. The data for this part of the program are also not available from real world application. Second, under ACC II (as currently submitted to EPA), CARB would allow for some banking of ZEV credits and credit pooling.[284] In the proposal, we did not assume compliance with ZEV requirements through banking of credits when simulating the program in the CAFE Model and focused instead on simulating manufacturer's deployment of ZEV consistent with ACC II fully through the production of new ZEVs, after conversations with CARB. In past rules, we assumed 80% compliance through vehicle requirements and the remaining 20% with banked credits.[285] In this rule, due to the complicated nature of accounting for the entire credit program, we focus only on incorporating CARB's allowance (as outlined in the ACC II program currently submitted to EPA) for manufacturers to use pooled credits in MYs 2026–2030 as part of their ZEV compliance in our modeling. Based on guidance from CARB in the NPRM and assessment of CARB's responses to manufacturer comments, we expect impacts of banked credit provisions on overall volumes to be small.[286]

TSD Chapter 2.5.1 includes more information about the process we use to simulate ACT program compliance and ZEV deployment consistent with ACC II in this analysis.

b. IRA Tax Credits

The IRA included several new and expanded tax credits intended to encourage the adoption of clean vehicles.[287] At the proposal stage, the agency was presented with three questions on how to incorporate the IRA. First, identifying which credits should be modeled. Next, determining the responses of consumers and producers to the subsidies. And finally determining which vehicles would qualify and how to value the credits. In its proposal, NHTSA modeled two provisions of the IRA. The first was the Advanced manufacturing production tax credit (AMPC). This provision provides a $35 per kWh tax credit for manufacturers of battery cells and an additional $10 per kWh for manufacturers of battery modules (all applicable to manufacture in the United States).[288] The second provision modeled in the proposal was the Clean vehicle credit (§ 30D),[289] which provides up to $7,500 toward the purchase of clean vehicles with critical minerals extracted or processed in the United States or a country with which the United States has a free trade agreement or recycled in North America, and battery components manufactured or assembled in North America.[173]

After NHTSA developed its methodology for incorporating the IRA tax credits into its analysis for the proposal, the Treasury Department clarified that leased vehicles qualify for the Credit for qualified commercial clean vehicles (§ 45W) and that the credit could be calculated based off of the DOE's Incremental Purchase Cost Methodology and Results for Clean Vehicles report for at least calendar year 2023 as a safe harbor, rather than having the taxpayer estimate the actual cost differential.[290] As a result, EPA modified their approach to modeling the IRA tax credits prior to finalizing their Multi-Pollutant Emissions Standards for Model Years 2027 and Later Light-Duty and Medium-Duty Vehicles proposal,

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[283] Valero, Docket No. NHTSA–2023–0022–58547–A8, at 3.

[284] CARB. 2022. Final Regulation Order: Section 1962.4, Title 13, California Code of Regulations. Available at: *https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2022/accii/acciifro1962.4.pdf.* (Accessed: Feb. 27, 2024).

[285] CAFE TSD 2024–2026. Pg. 129.

[286] CARB. 2022. Final Statement of Reasons for Rulemaking, Including Summary of Comments and Agency Response. Appendix C: Summary of Comments to ZEV Regulation and Agency Response. Available at: *https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2022/accii/fsorappc.pdf.* (Accessed: Feb. 27, 2024).

[287] Public Law No: 117–169.

[288] 26 U.S.C. 45X. If a manufacturer produces a battery module without battery cells, they are eligible to claim up to $45 per kWh for the battery module. Two other provisions of the AMPC are not modeled at this time; (i) a credit equal to 10 percent of the manufacturing cost of electrode active materials, (ii) a credit equal to 10 percent of the manufacturing cost of critical minerals for battery production. We are not modeling these credits directly because of how we estimate battery costs and to avoid the potential to double count the tax credits if they are included into other analyses that feed into our inputs. For a full account of the credit and any limitations, please refer to the statutory text.

[289] 26 U.S.C. 30D. For a full account of the credit and any limitations, please refer to the statutory text.

[290] See Internal Revenue Service. 2022. Frequently asked questions related to new, previously-owned and qualified commercial clean Vehicle credits. Q4 and Q8. Available at: *https://www.irs.gov/pub/taxpros/fs-2022-42.pdf.* (Accessed: Apr. 1, 2024).

however NHTSA was unable to incorporate a similar methodology in time for its proposal.

NHTSA noted in the proposal that there are several other provisions of the IRA related to clean vehicles that were excluded from the analysis, including the Previously-owned Clean Vehicle credit,[291] the Qualifying Advanced Energy Project credit (48C),[292] IRA § 50142 Advanced Technology Vehicle Manufacturing Loan Program, IRA § 50143 Domestic Manufacturing Conversion Grants, IRA § 70002 USPS Clean Fleets, and IRA § 13404 Alternative Fuel Vehicle Refueling Property Credit. As NHTSA noted in the proposal, these credits and grants incentivize clean vehicles through avenues the CAFE Model is currently unable to consider as they typically affect a smaller subset of the vehicle market and may influence purchasing decisions through means other than price, *e.g.,* through expanded charging networks. NHTSA also does not model individual state tax credits or rebate programs. Unlike ZEV requirements which are uniform across states that adopt them, state clean vehicle tax credits and rebates vary from jurisdiction to jurisdiction and are subject to more uncertainty than their Federal counterparts.[293] Tracking sales by jurisdiction and modeling each program's individual compliance program would require significant revisions to the CAFE Model and likely provide minimal changes in the net outputs of the analysis.

NHTSA sought comment from the public about which credits should be included in its analysis, and in particular whether the agency should include § 45W. Rivian and the American Council for an Energy Efficient Economy (ACEEE) both suggested that NHTSA also include § 45W in its analysis, to avoid underestimating the impact of the IRA on reference baseline technology adoption.[294] NHTSA did not receive any comments recommending either removing the AMPC or § 30D from its analysis, or advocating for other credits, Federal or State, to be included.

For the Final Rule, NHTSA models three of the IRA provisions in its analysis. NHTSA is again modeling the AMPC and, based on the recommendations of commenters and guidance from the Treasury Department indicating that § 45W applies to leased personal vehicles,[295] NHTSA decided to jointly model § 30D and § 45W (collectively, the Clean Vehicle Credits or ''CVCs'').[296] Both credits are available at the time of sale and provide up to $7,500 towards the purchase of light-duty and HDPUV PHEVs, BEVs, and FCEVs placed in service before the end of 2032. § 30D is only available to purchasers of vehicles assembled in North America and which meet certain sourcing requirements for critical minerals and battery components manufactured in North America.[297] § 45W is available for commercial purchasers of vehicles covered by this rule for a purpose other than resale. The credit value is the lesser of the incremental cost to purchase a comparable ICE vehicle or 15 percent of the cost basis for PHEVs or 30 percent of the cost basis for FCEVs and BEVs, up to $7,500 for vehicles with GVWR less than 14,000. Since only one of the CVCs may be claimed for purchasing a given vehicle, NHTSA modeled them jointly, employing a methodology similar to EPA's approach.

Interactions between producers and consumers in the marketplace tend to ensure that subsidies like the AMPC and the CVCs, regardless of whether they are initially paid to producers or consumers, are ultimately shared between the two groups. In the proposal, NHTSA assumed that manufacturers and consumers would each capture half the dollar value of each credit. NHTSA sought comment on its modeling assumptions related to how it modeled tax credits in the proposal. The Institute for Policy Integrity (IPI) suggested that NHTSA's assumptions about the incidence of tax credits were not compatible with its assumptions about the pass-through of changes in technology costs to consumers.[298] AFPM commented that IRA tax credits may be eliminated or modified, and that manufacturers may not pass the cost savings from the AMPC through to consumers.[299] NHTSA acknowledged uncertainty over its pass-through assumptions in its proposal and ran sensitivity cases which varied the degree to which these incentives are shared between consumers and manufacturers. NHTSA believes that changing the production quantities of these vehicles is a complex process that involves developing new supply chains and significant changes in production processes. As a result, NHTSA believes that manufacturers are likely to experience some motivation to recover these costs by attempting to capture some portion of IRA credits, for example, by raising prices of qualifying vehicles in response to availability of the 30D credit. On the other hand, NHTSA does not believe it is likely that manufacturers will be able to raise prices for these vehicles enough to fully capture the amount of credit in this way. NHTSA believes that the tax credits are likely to be a salient factor in the purchase decisions of consumers who purchase eligible vehicles and the § 30D credits have strict price eligibility constraints, which likely limits the ability of manufacturers to raise prices enough to fully capture the credits for vehicles whose sticker prices are close to the limit. NHTSA notes that the overall new vehicle market supply curve is the sum of all individual vehicle supply curves, which are presumed to be upward sloping. This means that the overall new vehicle supply curve will be more elastic than individual vehicle supply curves at all price levels. This means that any effective tax or subsidy that only hits a subset of vehicles will have a greater incidence on the producer. Finally, unlike technology improvements, the § 30D credits have income limits for eligibility. Thus, the effective price for buyers of these vehicles is not uniform since some potential buyers will be above this income limit and will not qualify for the credit (and may not wish to lease a vehicle in order to claim the § 45W credit). Since manufacturers cannot set different MSRP's based on the customer's income, the sticker prices they choose may reflect a balance between raising prices and not losing market share from potential customers who do not qualify for the credits. As

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[291] 26 U.S.C. 25E. For a full account of the credit and any limitations, please refer to the statutory text.

[292] 26 U.S.C. 48C. For a full account of the credit and any limitations, please refer to the statutory text.

[293] States have additional mechanisms to amend or remove tax incentives or rebates. Sometimes, even after these programs are enacted, uncertainty persists, see *e.g.* Farah, N. 2023. The Untimely Death of America's 'Most Equitable' EV Rebate. Last Revised: Jan. 30, 2023. Available at: *https://www.eenews.net/articles/the-untimely-death-of-americas-most-equitable-ev-rebate/.* (Accessed: May 31, 2023).

[294] Rivian, Docket No. NHTSA–2023–0022–28017, at 1; ACEEE, Docket No. NHTSA–2023–0022–60684, at 9.

[295] *See, e.g.,* Katten. Treasury Releases Guidance on Electric Vehicle Tax Credits (Jan. 3, 2023), available at *https://katten.com/treasury-releases-guidance-on-electric-vehicle-tax-credits.*

[296] 26 U.S.C. 45W. For a full account of the credit and any limitations, please refer to the statutory text.

[297] There are vehicle price and consumer income limitations on § 30D as well. See Congressional Research Service. 2022. Tax Provisions in the Inflation Reduction Act of 2022 (H.R. 5376). Available at: *https://crsreports.congress.gov/product/pdf/R/R47202/6.* (Accessed: May 31, 2023).

[298] IPI, Docket No. NHTSA–2023–0022–60485, at 23–24.

[299] AFPM, Docket No. NHTSA–2023–0022–61911, at 2.

a result, NHTSA believes that its split incidence of the credits represents a reasonable approach to modeling this policy. We believe that a similar logic applies to the AMPC where manufacturers operating in a competitive market will not be able to fully capture the tax credit. Many suppliers and OEMs work closely together through contractual agreements and partnerships, and these close connections promote fair pricing arrangements that prevent any *one* party from capturing the full value of the credit. With regard to the future existence of these tax credits, NHTSA conducted sensitivity analysis of a case in which the tax credits are not included in the analysis but does not believe that this should be treated as the central analysis since these incentives are currently being claimed and are scheduled to be available in the years that NHTSA analyzed.

For this analysis, the agency maintained its assumption from the proposal that manufacturers and consumers will each capture half of the dollar value of the AMPC and CVCs. The agency assumes that manufacturers' shares of both credits will offset part of the cost to supply models that are eligible for the credits—PHEVs, BEVs, and FCEVs. The subsidies reduce the costs of eligible vehicles and increase their attractiveness to buyers (however, in the LD fleet, the tax credits do not alter the penetration rate of BEVs in the regulatory alternatives).[300] Because the AMPC credit scales with battery capacity, NHTSA staff determined average battery energy capacity by powertrain (*e.g.,* PHEV, BEV, FCEV) for passenger cars, light trucks, and HDPUVs based on Argonne simulation outputs. For a more detailed discussion of these assumptions, see TSD Chapter 2.3.2. In the proposal NHTSA explained that it was unable to explicitly account for all of the eligibility requirements of § 30D and the AMPC, such as the location of final assembly and battery production, the origin of critical minerals, and the income restrictions of § 30D.[301] Instead, we account for these restraints through the credit schedules that are constructed in part based off of these factors and allow all PHEVs, BEVs, and FCEVs produced and sold during the time frame that tax credits are offered to be eligible for those credits subject to the MSRP restrictions discussed above.

To account for the agency's inability to dynamically model sourcing requirements and income limits for § 30D, NHTSA used projected values of the average value of § 30D and the AMPC for the proposal. The projections increased throughout the analysis due to the expectation that gradual improvements in supply chains over time would allow more vehicles to qualify for the credits. Commenters suggested that NHTSA's assumed values for the § 30D credit were too optimistic and did not reflect limitations that manufacturers face in adjusting their supply chains and component manufacturing processes to produce vehicles that qualify for the credit.[302] Similarly, some commenters argued that NHTSA did not adequately explain how it arrived at the credit estimates, did not offer any data to support the estimates, and failed to properly account for foreign entities of concern.[303]

To address the concerns raised by commenters, NHTSA is using an independent report performed by DOE for the Final Rule that provides combined values of the CVCs.[304] These values consider the latest information of EV penetration rates, EV retail prices, the share of US EV sales that meet the critical minerals and battery component requirements, the share of vehicles that exclude suppliers that are ''Foreign Entities of Concern'', and lease rates for vehicles that qualify for the § 45W CVC. The DOE projections are the most detailed and rigorous projections of credit availability that NHTSA is aware of at this time. According to DOE's analysis the average credit value for the CVCs across all PHEV, BEV, and FCEV sales in a given year will never reach its full $7,500 value for all vehicles, and instead project a maximum average credit value of $6,000. NHTSA is using the same projection for the average AMPC credit per kwh as in the proposal.

Similar to the proposal, the CAFE Model's approach to analyzing the effects of the CVCs includes a statutory restriction. The CAFE Model accounts for the MSRP restrictions of the § 30D by assuming that the CVCs cannot be applied to cars with an MSRP above $55,000 or other vehicles with an MSRP above $80,000, since these are ineligible for § 30D. § 45W does not have the same MSRP restrictions, however since NHTSA is unable to model the CVCs separately at this time, the agency had to choose whether to model the restriction for both CVCs or not to model the restriction at all. NHTSA chose to include the restriction for both CVCs to be conservative.[305] See Chapter 2.5.2 of the TSD for additional details on how NHTSA implements the IRA tax credits.

As the agency was coordinating with EPA and DOE on tax credits, NHTSA discovered that it was using nominal values for tax credits in the proposal instead of real dollars. NHTSA uses real dollars for future costs and benefits, such as technology costs in future model years. Including the tax credits as nominal dollars instead of real dollars artificially raises the value of the credits in respect to other costs. For the Final Rule, NHTSA has converted the DOE projections to real dollars.

As explained in the proposal, the CAFE model projects vehicles in model year cohorts rather than on a calendar year basis. Given that model years and calendar years can be misaligned, *e.g.,* a MY 24 vehicle could be sold in calendar years 2023, 2024, or even 2025, choosing which calendar year a model year falls into is important for assigning tax credits which are phased-out during the analytical period. In the proposal, NHTSA assumed that the majority of vehicles of a given model year would be sold in the calendar year that preceded it, *e.g.,* MY 2024 would largely be sold in calendar year 2023. NHTSA also noted at the time that there was a possible incentive for manufacturers to pull-up sales in the last calendar years that tax credits are available. NHTSA reanalyzed the timing of new vehicle sales and new vehicle registrations and determined that for the Final Rule it was appropriate to change its assumption that credits available in a given calendar year be available to all vehicles sold in the following model year. Instead, NHTSA decided to model vehicles in a given model year as eligible for credits available in the same calendar year. As a result, NHTSA applies the credits to MYs 2023–2032 in the analysis for both LDVs and HDPUVs.

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[300] In Table 9–4 of the FRIA, both the reference case (labeled ''RC'') and the no tax credit case (''No EV tax credits'') show a 32.3% penetration rate for BEVs in the baseline and preferred alternative.

[301] *See* 88 FR 56179 (Aug. 17, 2023) for a more detailed explanation of the process used for the proposal.

[302] CFDC et al., Docket No. NHTSA–2023–0022–62242, at 13–15; NATSO et al., Docket No. NHTSA–2023–0022–61070, at 4–5; UAW, Docket No. NHTSA–2023–0022–63061, at 3–4.

[303] CFDC et al, Docket No. NHTSA–2023–0022–62242–A1, at 3.

[304] U.S. Department of Energy.2024. Estimating Federal Tax Incentives for Heavy Duty Electric Vehicle Infrastructure and for Acquiring Electric Vehicles Weighing Less Than 14,000 Pounds. Memorandum, March 11, 2024.

[305] Bureau of Transportation Statisitics. New and Used Passenger Car and Light Truck Sales and Leases. Avaliable at: *https://www.bts.gov/content/new-and-used-passenger-car-sales-and-leases-thousands-vehicles.* (Accessed: Apr. 2, 2024).

6. Technology Applicability Equations and Rules

How does the CAFE Model decide how to apply technology to the analysis fleet of vehicles? We described above that the CAFE Model projects cost-effective ways that vehicle manufacturers could comply with CAFE standards, subject to limits that ensure that the model reasonably replicates manufacturer's decisions in the real-world. This section describes the equations the CAFE Model uses to determine how to apply technology to vehicles, including whether technologies are cost-effective, and why we believe the CAFE Model's calculation of potential compliance pathways reasonably represents manufacturers' decision-making. This section also gives a high-level overview of real-world limitations that vehicle manufacturers face when designing and manufacturing vehicles, and how we include those in the technology inputs and assumptions in the analysis.

The CAFE Model begins by looking at a manufacturer's fleet in a given MY and determining whether the fleet meets its CAFE standard. If the fleet does not meet its standard, the model begins the process of applying technology to vehicles. We described above how vehicle manufacturers use the same or similar engines, transmissions, and platforms across multiple vehicle models, and we track vehicle models that share technology by assigning Engine, Transmission, and Platform Codes to vehicles in the analysis fleet. As an example, the Ford 10R80 10-speed transmission is currently used in the following Ford Motor Company vehicles: 2017-present Ford F–150, 2018-present Ford Mustang, 2018-present Ford Expedition/Lincoln Navigator, 2019-present Ford Ranger, 2020-present Ford Explorer/Lincoln Aviator, and the 2020-present Ford Transit.[306] The CAFE Model first determines whether any technology should be ''inherited'' from an engine, transmission, or platform that currently uses the technology to a vehicle that is due for a refresh or redesign. Using the Ford 10R80 10-speed transmission analysis as applied to the CAFE Model, the above models would be linked using the same Transmission Code. Even though the vehicles might be eligible for technology applications in different years because each vehicle model is on a different refresh or redesign cycle, each vehicle could potentially inherit the 10R80 10-speed transmission. The model then again evaluates whether the manufacturer's fleet complies with its CAFE standard. If it does not, the model begins the process of evaluating what from our universe of technologies could be applied to the manufacturer's vehicles.

The CAFE Model applies the most cost-effective technology out of all technology options that could potentially be applied. To determine whether a particular technology is cost-effective, the model will calculate the ''effective cost'' of multiple technology options and choose the option that results in the lowest ''effective cost.'' The ''effective cost'' calculation is actually multiple calculations, but we only describe the highest levels of that logic here; interested readers can consult the CAFE Model Documentation for additional information on the calculation of effective cost. Equation III–6 shows the CAFE Model's effective cost calculation for this analysis.

$$EffCost = \frac{TechCost_{Total} - TaxCredits_{Total} - FuelSavings_{Total} - \Delta Fines}{\Delta ComplianceCredits}$$

Equation III-6: CAFE Model Effective Cost Calculation

Where:

$TechCost_{Total}$: the total cost of a candidate technology evaluated on a group of selected vehicles;

$TaxCredits_{Total}$: the cumulative value of additional vehicle and battery tax credits (or, Federal Incentives) resulting from application of a candidate technology evaluated on a group of selected vehicles;

$FuelSavings_{Total}$: the value of the reduction in fuel consumption (or, fuel savings) resulting from application of a candidate technology evaluated on a group of selected vehicles;

$\Delta Fines$: the change in manufacturer's fines in the analysis year if the CAFE compliance program is being evaluated, or zero if evaluating compliance with CO_2 standards;

$\Delta ComplianceCredits$: the change in manufacturer's compliance credits in the analysis year, which depending on the compliance program being evaluated, corresponds to the change in CAFE credits (denominated in thousands of gallons) or the change in CO_2 credits (denominated in metric tons); and

$EffCost$: the calculated effective cost attributed to application of a candidate technology evaluated on a group of selected vehicles.

For the effective cost calculation, the CAFE Model considers the total cost of a technology that could be applied to a *group* of connected vehicles, just as a vehicle manufacturer might consider what new technologies it has that are ready for the market, and which vehicles should and could receive the upgrade. Next, like the technology costs, the CAFE Model calculates the total value of Federal incentives (for this analysis, Federal tax credits) available for a technology that could be applied to a group of vehicles and subtracts that total incentive from the total technology costs. For example, even though we do not consider the fuel economy of LD BEVs in our standard-setting analysis, we do account for the costs of vehicles that manufacturers may build in response to California's ACC I program (and in the HDPUV analysis, the ACT program), and additional electric vehicles that manufacturers have committed to deploy (consistent with ACC II), as part of our evaluation of how the world would look without our regulation, or more simply, the regulatory reference baseline. If the CAFE Model is evaluating whether to build a BEV outside of the MYs for which NHTSA is setting standards (if applicable in the modeling scenario), it starts with the total technology cost for a group of BEVs and subtracts the total value of the tax credits that could be applied to that group of vehicles.

The total fuel savings calculation is slightly more complicated. Broadly, when considering total fuel savings from switching from one technology to another, the CAFE Model must calculate the total fuel cost for the vehicle before application of a technology and subtract the total fuel cost for the vehicle after calculation of that technology. The total fuel cost for a given vehicle depends on both the price of gas (or gasoline

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[306] DOE. 2013. Light-Duty Vehicles Technical Requirements and Gaps for Lightweight and Propulsion Materials. Final Report. Available at: *https://www.energy.gov/eere/vehicles/articles/workshop-reportlight-duty-vehicles-technical-requirements-and-gaps*. (Accessed: Feb. 27, 2024).

equivalent fuel) and the number of miles that a vehicle is driven, among other factors. As technology is applied to vehicles in groups, the total fuel cost is then multiplied by the sales volume of a vehicle in a MY to equal total fuel savings. This equation also includes an assumption that consumers are likely to buy vehicles with fuel economy-improving technology that pays for itself within 2.5 years, or 30 months. Finally, in the numerator, we subtract the change in a manufacturer's expected fines before and after application of a specific technology. Then, the result from the sequence above is divided by the change in compliance credits, which means a manufacturer's credits earned (expressed as thousands of gallons for the purposes of effective cost calculation) in a compliance category before and after the application of a technology to a group of vehicles.

The effective cost calculation has evolved over successive CAFE Model iterations to become increasingly more complex; however, manufacturers' decision-making regarding what fuel economy-improving technology to add to vehicles has also become increasingly more complex. We believe this calculation appropriately captures a number of manufacturers implicit or explicit considerations.

The model accounts explicitly for each MY, applying technologies when vehicles are scheduled to be redesigned or freshened and carrying forward technologies between MYs once they are applied. The CAFE Model accounts explicitly for each MY because manufacturers actually ''carry forward'' most technologies between MYs, tending to concentrate the application of new technology to vehicle redesigns or mid-cycle ''freshenings,'' and design cycles vary widely among manufacturers and specific products. Comments by manufacturers and model peer reviewers to past CAFE rules have strongly supported explicit year-by-year simulation. The multi-year planning capability, simulation of ''market-driven overcompliance,'' and EPCA credit mechanisms increase the model's ability to simulate manufacturers' real-world behavior, accounting for the fact that manufacturers will seek out compliance paths for several MYs at a time, while accommodating the year-by-year requirement. This same multi-year planning structure is used to simulate responses to standards defined in grams CO_2/mile and utilizing the set of specific credit provisions defined under EPA's program, when applicable in the modeling scenario.[307]

In addition to the model's technology application decisions pursuant to the compliance simulation algorithm, there are also several technology inputs and assumptions that work together to determine which technologies the CAFE Model can apply. The technology pathways, discussed in detail above, are one significant way that we instruct the CAFE Model to apply technology. Again, the pathways define technologies that are mutually exclusive (*i.e.,* that cannot be applied at the same time), and define the direction in which vehicles can advance as the modeling system evaluates specific technologies for application. Then, the arrows between technologies instruct the model on the order in which to evaluate technologies on a pathway, to ensure that a vehicle that uses a more fuel-efficient technology cannot downgrade to a less efficient option.

In addition to technology pathway logic, we have several technology applicability rules that we use to better replicate manufacturers' decision-making. The ''skip'' input—represented in the Market Data Input File as ''SKIP'' in the appropriate technology column corresponding to a specific vehicle model—is particularly important for accurately representing how a manufacturer applies technologies to their vehicles in the real world. This tells the model not to apply a specific technology to a specific vehicle model. SKIP inputs are used to simulate manufacturer decisions with cost-benefit in mind, including (1) parts and process sharing; (2) stranded capital; and (3) performance neutrality.

First, parts sharing includes the concepts of platform, engine, and transmission sharing, which are discussed in detail in Section II.C.2 and Section II.C.3, above. A ''platform'' refers to engineered underpinnings shared on several differentiated vehicle models and configurations. Manufacturers share and standardize components, systems, tooling, and assembly processes within their products (and occasionally with the products of another manufacturer) to manage complexity and costs for development, manufacturing, and assembly. Detailed discussion for this type of SKIP is provided in the ''adoption features'' section for different technologies, if applicable, in Chapter 3 of the TSD.

Similar to vehicle platforms, manufacturers create engines that share parts. For instance, manufacturers may use different piston strokes on a common engine block or bore out common engine block castings with different diameters to create engines with an array of displacements. Head assemblies for different displacement engines may share many components and manufacturing processes across the engine family. Manufacturers may finish crankshafts with the same tools to similar tolerances. Engines on the same architecture may share pistons, connecting rods, and the same engine architecture may include both six- and eight-cylinder engines. One engine family may appear on many vehicles on a platform, and changes to that engine may or may not carry through to all the vehicles. Some engines are shared across a range of different vehicle platforms. Vehicle model/configurations in the analysis fleet that share engines belonging to the same platform are identified as such, and we also may apply a SKIP to a particular engine technology where we know that a manufacturer shares an engine throughout several of their vehicle models, and the engine technology is not appropriate for any of the platforms that share the same engine.

It is important to note that manufacturers define common engines differently. Some manufacturers consider engines as ''common'' if the engines share an architecture, components, or manufacturing processes. Other manufacturers take a narrower definition, and only assume ''common'' engines if the parts in the engine assembly are the same. In some cases, manufacturers designate each engine in each application as a unique powertrain. For example, a manufacturer may have listed two engines separately for a pair that share designs for the engine block, the crank shaft, and the head because the accessory drive components, oil pans, and engine calibrations differ between the two. In practice, many engines share parts, tooling, and assembly resources, and manufacturers often coordinate design updates between two similar engines. We consider engines together (for purposes of coding, discussed in Section III.C.2 above, and for SKIP application) if the engines share a common cylinder count and configuration, displacement, valvetrain, and fuel type, or if the engines only differed slightly in compression ratio (CR), horsepower, and displacement.

Parts sharing also includes the concept of sharing manufacturing lines (the systems, tooling, and assembly

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[307] In this analysis, EPA's MYs 2022–2026 standards are included in the baseline, as discussed in more detail in Section IV.

processes discussed above), since manufacturers are unlikely to build a new manufacturing line to build a completely new engine. A new engine that is designed to be mass manufactured on an existing production line will have limits in number of parts used, type of parts used, weight, and packaging size due to the weight limits of the pallets, material handling interaction points, and conveyance line design to produce one unit of a product. The restrictions will be reflected in the usage of a SKIP of engine technology that the manufacturing line would not accommodate.

SKIPs also relate to instances of stranded capital when manufacturers amortize research, development, and tooling expenses over many years, especially for engines and transmissions. The traditional production life cycles for transmissions and engines have been a decade or longer. If a manufacturer launches or updates a product with fuel-saving technology, and then later replaces that technology with an unrelated or different fuel-saving technology before the equipment and research and development investments have been fully paid off, there will be unrecouped, or stranded, capital costs. Quantifying stranded capital costs accounts for such lost investments. One design where manufacturers take an iterative redesign approach, as described in a recent SAE paper,[308] is the MacPherson strut suspension. It is a popular low-cost suspension design and manufacturers use it across their fleet. As we observed previously, manufacturers may be shifting their investment strategies in ways that may alter how stranded capital could be considered. For example, some suppliers sell similar transmissions to multiple manufacturers. Such arrangements allow manufacturers to share in capital expenditures or amortize expenses more quickly. Manufacturers share parts on vehicles around the globe, achieving greater scale and greatly affecting tooling strategies and costs.

As a proxy for stranded capital, the CAFE Model accounts for platform and engine sharing and includes redesign and refresh cycles for significant and less significant vehicle updates. This analysis continues to rely on the CAFE Model's explicit year-by-year accounting for estimated refresh and redesign cycles, and shared vehicle platforms and engines, to moderate the cadence of technology adoption and thereby limit the implied occurrence of stranded capital and the need to account for it explicitly. In addition, confining some manufacturers to specific advanced technology pathways through technology adoption features acts as a proxy to indirectly account for stranded capital. Adoption features specific to each technology, if applied on a manufacturer-by-manufacturer basis, are discussed in each technology section. We discuss comments received on refresh and redesign cycles, parts-sharing, and SKIP logic below.

The National Resources Defense Council (NRDC) commented about several aspects of the redesign and refresh cycles included in the model. NRDC commented that we did not clearly explain why manufacturers' historic redesign cadences ''are representative of what manufacturers 'can' do if required,'' citing EPCA's command that each standard we set be the ''maximum feasible'' standard. NRDC gave several examples, like that ''NHTSA's historical data show that Ford and GM have redesigned heavier pickups every 6 years on average, Draft TSD at 2–29, but show Toyota taking 9 years on average.'' NRDC stated that ''[i]f it is feasible and practicable for two full-line manufacturers to redesign on a 6-year cadence, it is unclear why it is infeasible for others to do so as well.'' NRDC continued on to state that ''[t]he disparity between assumed redesign cycles for different automakers also appears to violate NHTSA's interpretation of 'economic practicability,' which ''has long abandoned the 'least capable manufacturer' approach. 88 FR at 56,314.'' NRDC also took issue with our interpretation that redesign cycles help us to account for stranded capital costs, which we do not explicitly include in our modeling, stating that ''[t]he possibility of even considerable stranded capital for some automakers–a reduced probability given the considerable lead time to MY2031 here–is not a per se 'harsh' economic consequence for the 'industry,' . . . that might render standards not economically practicable.'' NRDC requested that an alternative with reduced time between redesigns/refreshes should be modeled to compare the sensitivity of key metrics.[309] NRDC also expressed that NHTSA's sensitivity case allowing for annual redesigns is not instructive and questioned the reasons for including it and not a more realistic case.

NHTSA agrees with NRDC that refresh and redesign cycles are a significant input to the CAFE Model, and we understand that using refresh and redesign cycles to represent stranded capital that otherwise would be difficult to quantify has been a longstanding point of disagreement between the agency and NRDC. NHTSA continues to believe that the resources manufacturers spend on new vehicle technologies—including developing, testing, and deploying those technologies—represents a significant amount of capital, although that number may be declining because, like both NHTSA and NRDC mentioned, manufacturers are taking advantage of sharing suppliers and sharing parts (which NHTSA does model).

While NHTSA does observe different trends in development cycles for different manufacturers, the adoption of new technologies, particularly for major and advanced components, continues to require multiple years of investment before being deployed to production models. Table 2–9 in the TSD contains information about the percentage of a manufacturer's vehicle fleet that is expected to be redesigned. The contents reflect that each manufacturer has their own development schedules, which vary due to multiple factors including technological adoption trends and consumer acceptance in specific market segments.[310] [311] We also show the average redesign schedules for each technology class in the TSD, which similarly bears out this trend. On the other hand, as discussed further in Section VI, vehicle manufacturers in comment to the proposal reiterated that their ability to spend resources improving ICE vehicles between now and MY 2031 are limited in light of the need to spend resources on the BEV transition. NHTSA understands this to mean that the potential for the negative consequences of stranding capital is an even more important consideration to manufacturers than it may have been in previous rules. For purposes of this analysis, we believe that our refresh and redesign cycles are reasonable, for the reasons discussed in more detail below. If NHTSA were to reevaluate refresh/

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[308] Pilla, S. et al. 2021. Parametric Design Study of McPherson Strut to Stabilizer Bar Link Bracket Weld Fatigue Using Design for Six Sigma and Taguchi Approach. SAE Technical Paper 2021–01–0235. Available at: *https://doi.org/10.4271/2021-01-0235.* (Accessed: Feb. 27, 2024).

[309] Joint NGOs, Docket No. NHTSA–2023–0022–61944.

[310] An example of this is Nissan's Variable Compression Ratio engine that was first introduced in 2019 Infinity QX50 before it was expanded to other Nissan products few years later.

[311] Kojima, S. et al. 2018. Development of a New 2L Gasoline VC-Turbo Engine with the World's First Variable Compression Ratio Technology. SAE Technical Paper 2018–01–0371, Available at: *https://doi.org/10.4271/2018-01-0371.* (Accessed: Apr. 5, 2024).

redesign cycles, it would be as part of a future rulemaking action, in which all stakeholders would have the opportunity to comment.

That said, we disagree that the way that we apply refresh and redesign cycles in the model is contrary to EPCA and we disagree with the examples that NRDC provided to illustrate that point. Allowing some manufacturers to have longer product redesign cycles does not conflict with our statement that we should not be setting standards with reference to a least capable manufacturer. There are several reasons why a manufacturer could be the ''least capable'' in fuel economy space that have nothing to do with its vehicles' refresh or redesign cycles. Using the example of manufacturers that NRDC provided, NHTSA's analysis estimates that under the preferred alternative in MY 2031, Ford's light truck fleet achieves a fuel economy level of 42.6 mpg, exactly meeting their standard, GM's light truck fleet achieves a fuel economy level of 40.9 mpg, falling short of their standard by 0.9 mpg, while Toyota's light truck fleet achieves a fuel economy level of 50.2 mpg, exceeding their standard by 3.7 mpg.[312] Each manufacturer takes a different approach to redesigning its pickup trucks—Ford and GM every six years and Toyota every nine years—but on a fleet average basis, which is the relevant metric when considering fuel economy standards, each manufacturer's pickup design cycles are not indicative of their fleets' performance.

NRDC also stated that using historical average redesign cadences ''can obscure significant variation about the average,'' [313] using as an example the design window for the Ram 1500 and the Ram 1500 Classic in their comment—stating that ''[i]t is not clear how the automaker can feasibly update the 1500 every six years but not upgrade the 1500 Classic any faster than every 9 years.'' The most recent redesign of the Ram 1500 Classic was in 2009 and it will continue to be sold as-is for the 2024 model year.[314] Ram did update the 1500 in 2019 with a BISG system, but for reasons unique to Ram they decided to keep making the existing 1500 Classic. Since the manufacturer chose to keep the same product for 15 years, we cannot assume there would be a ''lost'' redesign window for this particular product. Note that the Ram 1500 Classic example is an extremely fringe example with a handful of other vehicles; as we showed in the Draft TSD and again in the Final TSD accompanying this rule, on average across the industry, manufacturers redesign vehicles every 6.6 years.

NRDC also commented about the interaction between redesign cycles and shared components, citing the Dodge Challenger as example of when ''a vehicle may go into a redesign window, yet not have major components such as engines upgraded, because the leader vehicle for that engine [the Ram 1500 Classic] has not yet entered its redesign window. NHTSA believes that NRDC's Dodge Challenger/Ram example to support using alternative redesign assumptions is an incomplete understanding of how the CAFE Model considers leader-follower relationships and redesigns. The CAFE Model considers each component separately when determining the most cost-effective path to compliance. Sticking to engines, the Dodge Challenger can accept four different engines, one of which is not used in any Ram truck.

NHTSA does consider the effect of reducing the time between redesigns and refreshes through a sensitivity case, the ''annual redesigns case,'' [315] which, as mentioned above, NRDC also took issue with. Perhaps we were not clear enough in the PRIA about the relative importance of this sensitivity case to our decision making, so we will clarify here. When we look at the annual redesign sensitivity case, we are examining the most extreme case of potential redesigns, explicitly not counting for the development, integration and manufacturing costs associated with such a cadence. Thus, this scenario is instructive of the upper bound of potential benefits under the assumption of unrestrained expenditures for vehicle design. While we agree that there are model outliers that could conceivably redesign closer to the average of six years, or even on an accelerated schedule of five years, we do not believe that we would see redesigns occurring, for example, any faster than three or four years. This is why we include planned vehicle refreshes in the modeling as well. Thus, the annual redesigns case is instructive because it shows us that any further refining of our redesign cadences (*i.e.,* on a scale between what we currently use and what we might consider reasonable for a lower bound schedule, which presumably would not be any shorter than the refresh schedule) would not have a significant impact on the analysis.

Like we maintain in other aspects of our analysis, some manufacturers' redesign cycles may be shorter than we model, and some manufacturers' redesign cycles may be longer than we model. We believe that it is reasonable to, on average, have our analysis reflect the capability of the industry. NHTSA will continue to follow industry trends in vehicle refresh and redesigns—like moving sales volume of an ICE model to a hybrid model, for example, or evaluating which technologies are now more frequently being applied during refreshes than redesigns—and consider how the refresh and redesign inputs could be updated in future analyses.[316]

NHTSA also received two comments related to parts sharing. The Institute for Policy Integrity (IPI) at New York University School of Law commented that ''NHTSA assumes that manufacturers apply the same costly technology to multiple models that share the same vehicle platform (*i.e.,* the car's essential design, engineering, and production components), while also (as noted above) maintaining their market shares irrespective of these cost changes.'' IPI stated that this assumption ''restricts manufacturers from optimizing their technology strategies,'' which leads the model to overstate compliance costs. Similarly, NRDC argued that ''NHTSA should reevaluate categorical restrictions on upgrading shared components on separate paths.'' NRDC included several examples of components shared on vehicles that it thought resulted in a vehicle not being updated with additional technology.

While the CAFE Model considers part sharing by manufacturers across vehicle platforms, this assumption is based on real-world observations of the latest vehicle markets (See TSD 2.2, The Market Data Input File). As mentioned in TSD Chapter 2.2.1, manufacturers are expected to share parts across platforms to take advantage of economies of scale. These factors prevent the CAFE Model

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[312] As a reminder, each manufacturer has a different projected standard based on the footprints and sales volumes of the vehicles it sells.

[313] We assume that NRDC means that using an average obscures large deviations from the average, but since we assign refresh and redesigns on a model level, not just at a manufacturer level, we can see where the deviations occur, and as discussed below in regards to this example, we believe these generally represent a small fraction of the fleet.

[314] Fitzgerald, J. 2024 The Ancient Ram 1500 Classic Returns for Another Year, Car and Driver. Last revised: Jan 5, 2024. Available at: *https://www.caranddriver.com/news/a46297349/2024-ram-1500-classic-confirmed/.* (Accessed: Apr. 5, 2024).

[315] See FRIA Chapter 9.2.2.1, Redesign Schedules.

[316] Just as vehicle manufacturers must spend significant resources to develop, test, and deploy new vehicle technologies, NHTSA must spend a significant amount of time (generally longer than that permitted in one CAFE rulemaking cycle) to develop, test, and deploy any new significant model update. We would also like, as mentioned above, for any update to our approach to redesign schedules to be subject to public comment for stakeholder feedback.

from predicting the adoption of unreasonably costly technologies across vehicle fleets.

While use of parts sharing by the CAFE Model is described as a restriction, we do not believe this is an accurate characterization. By considering upgrades across all vehicles that share a particular component, we are able to capture the total volume of that component in a way analogous to the manufacturers. If a potential upgrade is not cost-effective in the aggregate, it is unlikely that it would be cost-effective for a subset with a smaller volume.

IPI points to Mazda's MY 2032 estimated per-vehicle technology costs under alternative PC6LT8 as an example of an unrealistic outcome resulting from parts sharing. NHTSA maintains that this is an accurate projection of the effects of that regulatory alternative. The high per-vehicle costs in this specific case are due to a confluence of factors. The CAFE Model calculates the least expensive total regulatory cost, which includes both technology costs and fines. Mazda's preference to avoid fines in MY 2032 means that they would spend more on technology in order to comply with the standards. As a manufacturer, Mazda has an uncommonly high level of platform commonality, which means that investments in platform technology are likely to be propagated throughout their fleet in order to amortize costs more quickly. Their relatively small sales volume also drives up the per-vehicle costs. Taken together, these explain why the projected technology cost for Mazda is high, yet it is still within the same order of magnitude as some of Mazda's peer manufacturers (see FRIA Chapter 8). In the next most stringent regulatory alternative, Mazda's per-vehicle costs are projected to be in the middle of the pack compared to their peers.

NRDC also gave the example that the Dodge Challenger ''will be prevented from upgrading to any high-compression ratio (HCR) engine, because the [sales] leader Classic 1500 is categorically excluded from upgrading to an HCR engine in the CAFE model because it is a pickup truck'' as another example of the pitfalls of part sharing. NHTSA believes that this is a misreading of how the CAFE Model handles upgrade paths for shared components. The model restricts certain upgrade paths on the component level based on technology paths defined in TSD Chapter 3 and in this case, both the 1500 and the Challenger are only prevented from upgrading to a non-hybrid HCR engine. In the specific NRDC example, Engine Code 123602, a DOHC engine meant for high torque, was selected by Stellantis for, amongst other models, a pickup truck (Ram 1500 Classic) and a high-performance car (Dodge Challenger). HCR engines have higher efficiency at the cost of lower torque and lower power density, making them an unsuitable replacement for either model or any other model in this engine family. TSD Chapter 2.2.1, Characterizing Vehicles and their Technology Content has further information on how the CAFE Model applies SKIP logic. Also see TSD Chapter 3.1.1.2.3 for more information about HCR and Atkinson cycle engines.

NRDC also cited [an] ''example of an engine-sharing family in its 2018 fuel economy standards proposal included the Chevy Equinox SUV, which shared a 6-cylinder engine with the Colorado and Canyon pickups (along with other vehicles)'' that in later years ''did not maintain engine sharing.'' NHTSA stands by its position that historical data show manufacturers typically maintain parts commonality. The MY 2018 Chevy Equinox was available with two engines, a 4-cylinder and 6-cylinder, both naturally aspirated. The 4-cylinder variant was shared with the GMC Terrain and several Buick models which have since been discontinued, but not with the Chevy Colorado or GMC Canyon pickup trucks. This lineage was replaced by a choice of 1.5L or 2.0L 4-cylinder turbo engines in MY 2020 and now a single 1.5L 4-cylinder turbo in MY 2022. This engine is still shared between the Chevy Equinox and the GMC Terrain. In contrast, the Colorado and Canyon Pickups continue to use naturally aspirated engines in the 4-cylinder and 6-cylinder varieties, but these 4-cylinder engines are from a different lineage that were never shared with the Equinox. Instead of showing an example of manufacturers fracturing an existing engine family, this example validates our approach of considering technology upgrades at the component level.

Finally, we ensure that our analysis is performance neutral because the goal is to capture the costs and benefits of vehicle manufacturers adding fuel economy-improving technology *because* of CAFE standards, and not to inappropriately capture costs and benefits for changing other vehicle attributes that may have a monetary value associated with them.[317] This means that we ''SKIP'' some technologies where we can reasonably assume that the technology would not be able to maintain a performance attribute for the vehicle, and where our simulation over test cycles may not capture the technology limitation.

For example, prior to the development of SAE J2807, manufacturers used internal rating methods for their vehicle towing capacity. Manufacturers switched to the SAE tow rating standard at the next redesign of their respective vehicles so that they could mitigate costs via parts sharing and remain competitive in performance. Usually, the most capable powertrain configuration will also have the highest towing capacity and can be reflected in using this input feature. Separately, we also ensure that the analysis is performance neutral through other inputs and assumptions, like developing our engine maps assuming use with a fuel grade most commonly available to consumers.[318] Those assumptions are discussed throughout this section, and in Chapters 2 and 3 of the TSD. Technology ''phase-in caps'' and the ''phase-in start years'' are defined in the Technology Cost Input File and offer a way to gradually ''phase-in'' technology that is not yet fully mature to the analysis. They apply to the manufacturer's entire estimated production and, for each technology, define a share of production in each MY that, once exceeded, will stop the model from further applying that technology to that manufacturer's fleet in that MY.

The influence of these inputs varies with regulatory stringency and other model inputs. For example, setting the inputs to allow immediate 100 percent penetration of a technology will not guarantee any application of the technology if stringency increases are low and the technology is not at all cost effective. Also, even if these are set to allow only very slow adoption of a technology, other model aspects and inputs may nevertheless force more rapid application than these inputs, alone, would suggest (*e.g.,* because an engine technology propagates quickly due to sharing across multiple vehicles, or because BEV application must increase quickly in response to ZEV requirements). For this analysis, nearly all of these inputs are set at levels that do not limit the simulation at all.

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[317] *See, e.g.,* 87 FR 25887, citing EPA, Consumer Willingness to Pay for Vehicle Attributes: What is the Current State of Knowledge? (2018)). Importantly, the EPA-commissioned study ''found very little useful consensus'' on how consumers value various vehicle attributes, which they concluded were of little value in informing policy decisions.

[318] *See, e.g.,* 85 FR 24386. Please see the 2020 final rule for a significant discussion of how manufacturers consider fuel grades available to consumers when designing engines (including specific engine components).

This analysis also applies phase-in caps and corresponding start years to prevent the simulation from showing unlikely rates of applying battery-electric vehicles (BEVs), such as showing that a manufacturer producing very few BEVs in MY 2022 could plausibly replace every product with a 300- or 400-mile BEV by MY 2026. Also, this analysis applies phase-in caps and corresponding start years intended to ensure that the simulation's plausible application of the highest included levels of MR (20 percent reductions of vehicle ''glider'' weight) do not, for example, outpace plausible supply of raw materials and development of entirely new manufacturing facilities.

These model logical structures and inputs act together to produce estimates of ways each manufacturer could potentially shift to new fuel-saving technologies over time, reflecting some measure of protection against rates of change not reflected in, for example, technology cost inputs. This does not mean that every modeled solution would necessarily be economically practicable. Using technology adoption features like phase-in caps and phase-in start years is one mechanism that can be used so that the analysis better represents the potential costs and benefits of technology application in the rulemaking timeframe.

D. Technology Pathways, Effectiveness, and Cost

The previous section discussed, at a high level, how we generate the technology inputs and assumptions used in the CAFE Model. We do this in several ways: by evaluating data submitted by vehicle manufacturers; consolidating publicly available data, press materials, marketing brochures, and other information; collaborative research, testing, and modeling with other Federal agencies; research, testing, and modeling with independent organizations; determining that work done for prior rules is still relevant and applicable; considering feedback from stakeholders on prior rules and meetings conducted prior to the commencement of this rulemaking; and using our own engineering judgment.

This section discusses the specific technology pathways, effectiveness, and cost inputs and assumptions used in the compliance analysis. As an example, interested readers learned in the previous section that the starting point for estimating technology costs is an estimate of the DMC—the component and assembly costs of the physical parts and systems that make up a complete vehicle—for any particular technology; in this section, readers will learn that our transmission technology DMCs are based on estimates from the NAS.

After spending over a decade refining the technology pathways, effectiveness, and cost inputs and assumptions used in successive CAFE Model analyses, we have developed guiding principles to ensure that the CAFE Model's compliance analysis results in impacts that we would reasonably expect to see in the real world. These guiding principles are as follows:

Technologies will have complementary or non-complementary interactions with the full vehicle technology system. The fuel economy improvement from any individual technology must be considered in conjunction with the other fuel economy-improving technologies applied to the vehicle, because technologies added to a vehicle will not result in a simple additive fuel economy improvement from each individual technology. In particular, we expect this result from engine and other powertrain technologies that improve fuel economy by allowing the ICE to spend more time operating at efficient engine speed and load conditions, or from combinations of engine technologies that work to reduce the effective displacement of the engine.

The effectiveness of a technology depends on the type of vehicle the technology is being applied to. When we talk about ''vehicle type'' in our analysis, we're referring to our vehicle technology classes—*e.g.,* a small car, a medium performance SUV, or a pickup truck, among other classes. A small car and a medium performance SUV that use the exact same technology will start with very different fuel economy values; so, when the exact same technology is added to both of those vehicles, the technology will provide a different effectiveness improvement on both of those vehicles.

The cost and effectiveness values for each technology should be reasonably representative of what can be achieved across the entire industry. Each technology model employed in the analysis is designed to be representative of a wide range of specific technology applications used in industry. Some manufacturers' systems may perform better or worse than our modeled systems and some may cost more or less than our modeled systems; however, employing this approach will ensure that, on balance, the analysis captures a reasonable level of costs and benefits that would result from any manufacturer applying the technology.

A consistent reference point for cost and effectiveness values must be identified before assuming that a cost or effectiveness value could be employed for any individual technology. For example, as discussed below, this analysis uses a set of engine map models that were developed by starting with a small number of engine configurations, and then, in a very systematic and controlled process, adding specific well-defined technologies to create a new map for each unique technology combination. Again, providing a consistent reference point to measure incremental technology effectiveness values ensures that we are capturing accurate effectiveness values for each technology combination.

The following sections discuss the engine, transmission, electrification, MR, aerodynamic, ROLL, and other vehicle technologies considered in this analysis. The following sections discuss:

- How we define the technology in the CAFE Model,[319]
- How we assigned the technology to vehicles in the analysis fleet used as a starting point for this analysis,
- Any adoption features applied to the technology, so the analysis better represents manufacturers' real-world decisions,
- The technology effectiveness values, and
- Technology cost.

Please note that the following technology effectiveness sections provide *examples* of the *range* of effectiveness values that a technology could achieve when applied to the entire vehicle system, in conjunction with the other fuel economy-improving technologies already in use on the vehicle. To see the incremental effectiveness values for any particular vehicle moving from one technology key to a more advanced technology key, see the CAFE Model Fuel Economy Adjustment Files that are installed as part of the CAFE Model Executable File, and not in the input/output folders. Similarly, the technology costs provided in each section are *examples* of absolute costs seen in specific MYs, for specific vehicle classes. Please refer to the Technologies Input File to see all absolute technology costs used in the analysis across all MYs.

For the LD analysis we show two sets of technology effectiveness charts for each technology type, titled ''Unconstrained'' and ''Standard Setting.'' For the Standard Setting charts, effectiveness values reflect the application of 49 U.S.C. 32902(h)

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[319] Note, due to the diversity of definitions industry sometimes employs for technology terms, or in describing the specific application of technology, the terms defined here may differ from how the technology is defined in the industry.

considerations to the technologies; for example, PHEV technologies only show the effectiveness achieved when operating in a gasoline only mode (charge sustaining mode). The Unconstrained charts show the effectiveness values modeled for the technologies without the 49 U.S.C; 32902(h) constraints; when unconstrained, PHEV technologies show effectiveness for their full dual fuel use functionality. The standard setting values are used during the standard setting years being assessed in this analysis, and the unconstrained values are used for all other years.

1. Engine Paths

ICEs convert chemical energy in fuel to useful mechanical power. The chemical energy in the fuel is released and converted to mechanical power by being oxidized, or burned, inside the engine. The air/fuel mixture entering the engine and the burned fuel/exhaust by-products leaving the engine are the working fluids in the engine. The engine power output is a direct result of the work interaction between these fluids and the mechanical components of the engine.[320] The generated mechanical power is used to perform useful work, such as vehicle propulsion. For a complete discussion on fundamentals of engine characteristics, such as torque, torque maps, engine load, power density, brake mean effective pressure (BMEP), combustion cycles, and components, please refer to *Heywood* 2018.[321]

We classify the extensive variety of both LD and HDPUV vehicle ICE technologies into discrete Engine Paths. These paths are used to model the most representative characteristics, costs, and performance of the fuel economy-improving engine technologies most likely available during the rulemaking time frame. The paths are intended to be representative of the range of potential performance levels for each engine technology. In general, the paths are tied to ease of implementation of additional technology and how closely related the technologies are. The technology paths for LD and HDPUV can be seen in Chapter 3.1.1 of the TSD.

The LD Engine Paths have been selected and refined over a period of more than ten years, based on engines in the market, stakeholder comments, and our engineering judgment, subject to the following factors: we included technologies most likely available during the rulemaking time frame and the range of potential performance levels for each technology, and excluded technologies unlikely to be feasible in the rulemaking timeframe, technologies unlikely to be compatible with U.S. fuels, or technologies for which there was not appropriate data available to allow the simulation of effectiveness across all vehicle technology classes in this analysis.

For technologies on the HDPUV Engine Paths, we revisited work done for the HDPUV analysis in the Phase 2 rulemaking. We have updated our HDPUV Engine Paths based on that work, the availability of technology in the HDPUV analysis fleet, and technologies we believe will be available in the rulemaking timeframe. The HDPUV fleet is significantly smaller than the LD fleet with the majority of vehicles being produced by only three manufacturers, General Motors, Ford, and Stellantis. These vehicles include work trucks and vans that are focused on transporting people and moving equipment and supplies and tend to be more focused on a common need than that of vehicles in the LD fleet, which includes everything from sports cars to commuter cars and pickup trucks. The engine options between the two fleets are different in the real world and are accordingly different in the analysis. HDPUVs are work vehicles and their engines must be able to handle additional work such as higher payloads, towing, and additional stop and go demands. This results in HDPUVs often requiring larger, more robust, and more powerful engines. As a result of the HDPUV's smaller fleet size and narrowed focus, fewer engines and engine technologies are developed or used in this fleet. That said, we believe that the range of technologies included in the HDPUV Engine Paths and Electrification/Hybrid/Electrics Path discussed in Section III.D.3 of this preamble presents a reasonable representation of powertrain options available for HDPUVs now and in the rulemaking time frame.

The Engine Paths begin with one of the three base engine configurations: dual over-head camshaft (DOHC) engines have two camshafts per cylinder head (one operating the intake valves and one operating the exhaust valves), single over-head camshaft (SOHC) engines have a single camshaft, and over-head valve (OHV) engines also have a single camshaft located inside of the engine block (south of the valves rather than over-head) connected to a rocker arm through a push rod that actuates the valves. DOHC and SOHC engine configurations are common in the LD fleet, while OHV engine configurations are more common in the HDPUV fleet.

The next step along the Engine Paths is at the Basic Engine Path technologies. These include variable valve lift (VVL), stoichiometric gasoline direct injection (SGDI), and a basic level of cylinder deactivation (DEAC). VVL dynamically adjusts how far the valve opens and reduces fuel consumption by reducing pumping losses and optimizing airflow over broader range of engine operating conditions. Instead of injecting fuel at lower pressures and before the intake valve, SGDI injects fuel directly into the cylinder at high pressures allowing for more precise fuel delivery while providing a cooling effect and allowing for an increase in the CR and/or more optimal spark timing for improved efficiency. DEAC disables the intake and exhaust valves and turns off fuel injection and spark ignition on select cylinders which effectively allows the engine to operate temporarily as if it were smaller while also reducing pumping losses to improve efficiency. New for the NPRM and carried into this final rule analysis is that variable valve timing (VVT) technology is integrated in all non-diesel engines, so we do not have a separate box for it on the Basic Engine Path. For the LD analysis, VVL, SGDI, and DEAC can be applied to an engine individually or in combination with each other, and for the HDPUV analysis, SGDI and DEAC can be applied individually or in combination.

Moving beyond the Basic Engine Path technologies are the "advanced" engine technologies, which means that applying the technology—both in our analysis and in the real world—would require significant changes to the structure of the engine or an entirely new engine architecture. The advanced engine technologies represent the application of alternate combustion cycles, various applications of forced induction technologies, or advances in cylinder deactivation.

Advanced cylinder deactivation (ADEAC) systems, also known as rolling or dynamic cylinder deactivation systems, allow the engine to vary the percentage of cylinders deactivated and the sequence in which cylinders are deactivated. Depending on the engine's speed and associated torque requirements, an engine might have most cylinders deactivated (*e.g.,* low torque conditions as with slower speed driving) or it might have all cylinders activated (*e.g.,* high torque conditions as

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[320] Heywood, John B. Internal Combustion Engine Fundamentals. McGraw-Hill Education, 2018. Chapter 1.

[321] Heywood, John B. Internal Combustion Engine Fundamentals. McGraw-Hill Education, 2018.

with merging onto a highway).[322] An engine operating at low speed/low torque conditions can then save fuel by operating as if it is only a fraction of its total displacement. We model two ADEAC technologies, advanced cylinder deactivation on a single overhead camshaft engine (ADEACS), and advanced cylinder deactivation on a dual overhead camshaft engine (ADEACD).

Forced induction gasoline engines include both supercharged and turbocharged downsized engines, which can pressurize or force more air into an engine's intake manifold when higher power output is needed. The raised pressure results in an increased amount of airflow into the cylinder supporting combustion, increasing the specific power of the engine. The first-level turbocharged downsized technology (TURBO0) engine represents a basic level of forced air induction technology being applied to a DOHC engine. Cooled exhaust gas recirculation (CEGR) systems take engine exhaust gasses and passes them through a heat exchanger to reduce their temperature, and then mixes them with incoming air in the intake manifold to reduce peak combustion temperature and effect fuel efficiency and emissions. We model the base TURBO0 turbocharged engine with the addition of cooled exhausted recirculation (TURBOE), basic cylinder deactivation (TURBOD), and advanced cylinder deactivation (TURBOAD). Advancing further into the Turbo Engine Path leads to engines that have higher BMEP, which is a function of displacement and power. The higher the BMEP, the higher the engine performance. We model two levels of advanced turbocharging technology (TURBO1 and TURBO2) that run increasingly higher turbocharger boost levels, burning more fuel and making more power for a given displacement. As discussed above, we pair turbocharging with engine downsizing, meaning that the turbocharged downsized engines in our analysis improve vehicle fuel economy by using less fuel to power the smaller engine while maintaining vehicle performance.

NHTSA received a limited number of comments on forced induction gasoline engines. The comments seemed to highlight some misunderstandings of our forced induction pathway rather than the technology itself and how it was applied in our analysis for this rulemaking. In discussing the turbocharged pathway NRDC commented, ''. . . NHTSA has not appropriately considered the relative efficiency of these engines with respect to each other when designing its technology pathways. As a result, the technology pathway does not reasonably reflect an appropriate consideration of the full availability of turbocharged engine improvements.''

NRDC assumed that the pathways are in order from least effective to most effective,[323] however, this is not how the technologies are arranged in the pathway. The technology pathways represent an increase in the level or combinations of technologies being applied, with lower levels at the top and higher levels at the bottom of the path. Chapter 3.1.1 of the TSD shows the technology pathways for visualization purposes, however the CAFE Model could apply any cost-effective combinations of technologies from those given pathways. Levels of improvement are dependent upon the vehicle class and the technology combinations. As a reminder, we stated in the NPRM section describing the technology pathways just before the figure of the technology tree that ''[i]n general, the paths are tied to ease of implementation of additional technology and how closely related the technologies are.''[324] An example of how this applies to the TURBO family of technologies is described below. To the extent that the verbiage around the technology tree was confusing, we will endeavor to make that clearer moving forward. The pathways are not aligned from ''least effective'' to ''most effective'' because assuming so would ignore several important considerations, including how technologies interact on a vehicle, how technologies interact on vehicles of different sizes that have different power requirements, and how hardware changes may be required for a particular technology (see above, ''ease of implementation of additional technology,'' and the related example below that describes how once a manufacturer downsizes an engine accompanying the application of a turbocharger, it would most likely not then re-upsize the engine to add a less advanced turbocharger). The interaction of these technology combinations is discussed in more details in TSD Chapter 2.

While we have modeled TURBO0 with cooled EGR (TURBOE) and with DEAC (TURBOD), NRDC is correct that we do not apply these technologies to TURBO1 or TURBO2; this decision was intentional and not a lapse in engineering judgment, as NRDC seems to imply. We define TURBO1 in our analysis by adding VVL to the TURBO0 engine, and TURBO2 is our highest turbo downsized engine with a high BMEP. The benefits of cooled EGR and DEAC on TURBO1 and TURBO2 technologies would occur at high engine speeds and loads, which do not occur on the two-cycle tests. Because technology effectiveness in our analysis is measured based on the delta in improvements in vehicles' two-cycle test fuel consumption values, adding cooled EGR and DEAC to TURBO1 and TURBO2 would provide little effectiveness improvement in our analysis with a corresponding increase in cost that we do not believe manufacturers would adopt in the real world. These complex interactions among technologies are effectively captured in our modeling and this is an example of why we do not simply add effectiveness values from different technologies together.[325] This potential for added costs with limited efficiency benefit is also an example of why we do not order our technology tree from least to most effective technology, and we choose to include particular technologies on the technology tree and not others. For more discussion on interactions among individual technologies in the full vehicle simulations, see TSD Chapter 2.

NRDC also believes the model is improperly constrained because it cannot apply lower levels of technology over higher levels, which results in a situation where vehicles in the analysis fleet that have been assigned higher levels of turbocharging technology cannot adopt what NRDC alleges to be a more efficient turbocharged engine technology. For example, the model does not allow a vehicle assigned a TURBO2 technology to adopt a TURBOE technology. A vehicle in the analysis fleet that is assigned the TURBO2 technology tells us a manufacturer made the decision to either skip over or move on from lower levels of force induction technology. Moving backwards in the technology tree from TURBO2 to any of the lower turbo technologies would require the engine to be upsized to meet the same performance metrics as the analysis fleet vehicle. As discussed further in Section III.C.6, we ensure the vehicles in our analysis meet similar performance

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[322] See for example, Dynamic Skip Fire, Tula Technology, DSF in real world situations, *https://www.tulatech.com/combustion-engine/*. Our modeled ADEAC system is not based on this specific system, and therefore the effectiveness improvement will be different in our analysis than with this system, however, the theory still applies.

[323] NRDC, Docket No. NHTSA–2023–0022–61944–A2, at 13.

[324] 88 FR 56159 (Aug. 17, 2023).

[325] NHTSA–2021–0053–0007–A3, at 15; NHTSA–2021–0053–0002–A9, at 21–23.

levels after the application of fuel economy-improving technology because we want to measure the costs and benefits of manufacturers responding to CAFE standards in our analysis, and not the costs or benefits related to changing performance metrics in the fleet. Moving from a higher to a lower turbo technology works counter to saving fuel as the engine would grow in displacement requiring more fuel, adding frictional losses, and increasing weight and cost. While fuel economy is important to manufacturers, it is not the only parameter that drives engine or technology selection, and it goes against the industry trends for downsized engines.[326] Accordingly, we believe that our Turbo engine pathway appropriately captures the ways manufacturers might apply increasing levels of turbocharging technology to their vehicles.

In this analysis, high compression ratio (HCR) engines represent a class of engines that achieve a higher level of fuel efficiency by implementing a high geometric CR with varying degrees of late intake valve closing (LIVC) (*i.e.,* closing the intake valve later than usual) using VVT, and without the use of an electric drive motor.[327] These engines operate on a modified Atkinson cycle allowing for improved fuel efficiency under certain engine load conditions but still offering enough power to not require an electric motor; however, there are limitations on how HCR engines can apply LIVC and the types of vehicles that can use this technology. The way that each individual manufacturer implements a modified Atkinson cycle will be unique, as each manufacturer must balance not only fuel efficiency considerations, but emissions, on-board diagnostics, and safety considerations that includes the vehicle being able to operate responsively to the driver's demand.

We define HCR engines as being naturally aspirated, gasoline, SI, using a geometric CR of 12.5:1 or greater,[328] and able to dynamically apply various levels of LIVC based on load demand. An HCR engine uses less fuel for each engine cycle, which increases fuel economy, but decreases power density (or torque). Generally, during high loads—when more power is needed—the engine will use variable valve actuation to reduce the level of LIVC by closing the intake valve earlier in the compression stroke (leaving more air/fuel mixture in the combustion chamber), increasing the effective CR, reducing over-expansion, and sacrificing efficiency for increased power density.[329] However, there is a limit to how much the air-fuel mixture can be compressed before ignition in the HCR engine due to the potential for engine knock [330] Engine knock can be mitigated in HCR engines with higher octane fuel, however, the fuel specified for use in most vehicles is not this higher octane fuel. Conversely, at low loads the engine will typically increase the level of LIVC by closing the intake valve later in the compression stroke, reducing the effective CR, increasing the over-expansion, and sacrificing power density for improved efficiency. By closing the intake valve later in the compression stroke (*i.e.,* applying more LIVC), the engine's displacement is effectively reduced, which results in less air and fuel for combustion and a lower power output.[331] Varying LIVC can be used to mitigate, but not eliminate, the low power density issues that can constrain the application of an Atkinson-only engine.

When we say, ''lower power density issues,'' this translates to a low torque density,[332] meaning that the engine cannot create the torque required at necessary engine speeds to meet load demands. To the extent that a vehicle requires more power in a given condition than an engine with low power density can provide, that engine would experience issues like engine knock for the reasons discussed above, but more importantly, an engine designer would not allow an engine application where the engine has the potential to operate in unsafe conditions in the first place. Instead, a manufacturer could significantly increase an engine's displacement (*i.e.,* size) to overcome those low power density issues,[333] or could add an electric motor and battery pack to provide the engine with more power, but a far more effective pathway would be to apply a different type of engine technology, like a downsized, turbocharged engine.[334]

Vehicle manufacturers' intended performance attributes for a vehicle—like payload and towing capability, features for off-road use, and other attributes that affect aerodynamic drag and rolling resistance—dictate whether an HCR engine can be a suitable technology choice for that vehicle.[335] As vehicles require higher payloads and towing capacities,[336] or experience road load increases from larger all-terrain tires, a less aerodynamic design, or experience driveline losses for AWD and 4WD configurations, more engine torque is required at all engine speeds. Any time more engine torque is required the application of HCR technology becomes less effective and more limited.[337] For these reasons, and to

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[326] 2023 EPA Trends Report.

[327] Late intake valve closing (LIVC) is a method manufacturers use to reduce the effective compression ratio and allow the expansion ratio to be greater than the compression ratio resulting in improved fuel economy but reduced power density. Further technical discussion on HCR and Atkinson Engines are discussed in TSD Chapter 3.1.1.2.3. See the 2015 NAS report, Appendix D, for a short discussion on thermodynamic engine cycles.

[328] Note that even if an engine has a compression ratio of 12.5:1 or greater, it does not necessarily mean it is an HCR engine in our analysis, as discussed below. We look at a number of factors to perform baseline engine assignments.

[329] Variable valve actuation is a general term used to describe any single or combination of VVT, VVL, and variable valve duration used to dynamically alter an engines valvetrain during operation.

[330] Engine knock in spark ignition engines occurs when combustion of some of the air/fuel mixture in the cylinder does not result from propagation of the flame front ignited by the spark plug, but one or more pockets of air/fuel mixture explodes outside of the envelope of the normal combustion front.

[331] Power = (force × displacement)/time.

[332] Torque = radius × force.

[333] But see the 2023 EPA Trends Report at 48 (''As vehicles have moved towards engines with a lower number of cylinders, the total engine size, or displacement, is also at an all-time low.''), and the discussion below about why we do not believe manufacturers will increase the displacement of HCR engines to make the necessary power because of the negative impacts it has on fuel efficiency.

[334] *See, e.g.,* Toyota Newsroom. 2023. 2024 Toyota Tacoma Makes Debut on the Big Island, Hawaii. Available at: *https://pressroom.toyota.com/2024-toyota-tacoma-makes-debut-on-the-big-island-hawaii/*. (Accessed: Feb. 28, 2024). The 2024 Toyota Tacoma comes in 8 ''grades,'' all of which use a turbocharged engine.

[335] Supplemental Comments of Toyota Motor North America, Inc., Notice of Proposed Rulemaking: Safer Affordable Fuel-Efficient Vehicles Rule, Docket ID Numbers: NHTSA–2018–0067 and EPA–HQ–OAR–2018–0283, at 6; Feng, R. et al. 2016. Investigations of Atkinson Cycle Converted from Conventional Otto Cycle Gasoline Engine. SAE Technical Paper 2016–01–0680. Available at: *https://www.sae.org/publications/technical-papers/content/2016-01-0680/*. (Accessed: Feb. 28, 2024).

[336] See Tucker, S. 2023. What Is Payload: A Complete Guide. Kelly Blue Book. Last revised: Feb. 2, 2023. Availale at: *https://www.kbb.com/car-advice/payload-guide/#link3*. (Accessed: Feb. 28, 2024). (''Roughly speaking, payload capacity is the amount of weight a vehicle can carry, and towing capacity is the amount of weight it can pull. Automakers often refer to carrying weight in the bed of a truck as hauling to distinguish it from carrying weight in a trailer or towing.'').

[337] Supplemental Comments of Toyota Motor North America, Inc., Notice of Proposed Rulemaking: Safer Affordable Fuel-Efficient Vehicles Rule, Docket ID Numbers: NHTSA–2018–0067 and EPA–HQ–OAR–2018–0283. (''Tacoma has a greater coefficient of drag from a larger frontal area, greater tire rolling resistance from larger tires with a more aggressive tread, and higher driveline losses from 4WD. Similarly, the towing, payload, and off road capability of pick-up trucks necessitate greater emphasis on engine torque and horsepower over fuel economy. This translates into engine specifications such as a larger displacement and a higher stroke-to-bore ratio. . . . Tacoma's higher road load and more severe utility requirements push engine operation more frequently to the less efficient regions of the engine map and limit the level of Atkinson operation . . . This endeavor is

Continued

maintain a performance-neutral analysis and as discussed further below, we limit non-hybrid and non-plug-in-hybrid HCR engine application to certain categories of vehicles.[338] Also for these reasons, HCR engines are not found in the HDPUV analysis fleet nor are they available as an engine option in the HDPUV analysis.

For this analysis, our HCR Engine Path includes three technology options: (1) a first-level Atkinson-enabled engine (HCR) with VVT and SGDI, (2) an Atkinson enabled engine with cooled exhaust gas recirculation (HCRE), and finally, (3) the Atkinson enabled engine with DEAC (HCRD). This updated family of HCR engine map models also reflects our statement in NHTSA's May 2, 2022 final rule that a single engine that employs an HCR, CEGR, *and* DEAC ''is unlikely to be utilized in the rulemaking timeframe based on comments received from the industry leaders in HCR technology application.'' [339]

These three HCR Engine Path technology options (HCR, HCRE, HCRD) should not be confused with the hybrid and plug-in hybrid electric pathway options that also utilize HCR engines in combination with an P2 hybrid powertrain (*i.e.,* P2HCR, P2HCRE, PHEV20H, and PHEV50H); those hybridization path options are discussed in Section III.D.3, below. In contrast, Atkinson engines in our powersplit hybrid powertrains (SHEVPS, PHEV20PS, and PHEV50PS) for this analysis run the Atkinson Cycle full time but are connected to an electric motor. The full-time Atkinson engines are also discussed in Section III.D.3.

The Miller cycle is another alternative combustion cycle that effectively uses an extended expansion stroke, similar to the Atkinson cycle but with the application of forced induction, to improve fuel efficiency. Miller cycle-enabled engines have a similar trade-off in power density as Atkinson engines; the lower power density requires a larger volume engine in comparison to an Otto cycle-based turbocharged system for similar applications.[340] To address the impacts of the extended expansion stroke on power density during high load operating conditions, the Miller cycle operates in combination with a forced induction system. In our analysis, the first-level Miller cycle-enabled engine includes the application of variable turbo geometry technology (VTG), or what is also known as a variable-geometry turbocharger. VTG technology allows for the adjustment of key geometric characteristics of the turbocharging system, thus allowing adjustment of boost profiles and response based on the engine's operating needs. The adjustment of boost profile during operation increases the engine's power density over a broader range of operating conditions and increases the functionality of a Miller cycle-based engine. The use of a variable geometry turbocharger also supports the use of CEGR. The second level of VTG engine technology in our analysis (VTGE) is an advanced Miller cycle-enabled system that includes the application of at least a 40V-based electronic boost system. An electronic boost system has an electric motor added to assist the turbocharger; the motor assist mitigates turbocharger lag and low boost pressure by providing the extra boost needed to overcome the torque deficit at low engine speeds.

Variable compression ratio (VCR) engines work by changing the length of the piston stroke of the engine to optimize the CR and improve thermal efficiency over the full range of engine operating conditions. Engines that use VCR technology are currently in production as small displacement turbocharged in-line four-cylinder, high BMEP applications.

Diesel engines have several characteristics that result in better fuel efficiency over traditional gasoline engines, including reduced pumping losses due to lack of (or greatly reduced) throttling, high pressure direct injection of fuel, a combustion cycle that operates at a higher CR, and a very lean air/fuel mixture relative to an equivalent-performance gasoline engine. However, diesel technologies require additional systems to control NO_X emissions, such as a NO_X adsorption catalyst system or a urea/ammonia selective catalytic reduction system. We included two levels of diesel engine technology in both the LD and HDPUV analyses: the first-level diesel engine technology (ADSL) is a turbocharged diesel engine, and the more advanced diesel engine (DSLI) adds DEAC to the ADSL engine technology. The diesel engine maps are new for this analysis. The LD diesel engine maps and HD van engine maps are based on a modern 3.0L turbo-diesel engine, and the HDPUV pickup truck engine maps are based on a larger 6.7L turbo-diesel engine.

Finally, compressed natural gas (CNG) systems are ICEs that run on natural gas as a fuel source. The fuel storage and supply systems for these engines differ tremendously from gasoline, diesel, and flex fuel vehicles.[341] The CNG engine option has been included in past analyses; however, the LD and HDPUV analysis fleets do not include any dedicated CNG vehicles. As with the last analyses, CNG engines are included as an analysis fleet-only technology and are not applied to any vehicle that did not already include a CNG engine.

We received several comments that gave examples of vehicle technologies that work in various ways to improve fuel efficiency, some of which we use in our analysis and some we do not. MECA gave us several examples of fuel efficiency technologies that we use in our analysis such as cylinder deactivation, VVT and VVL, VTG, and VTGe.[342] MECA also discussed technologies we do not use in the analysis such as turbo compounding. Similarly, ICCT gave examples of technology such as negative valve overlap in-cylinder fuel reforming (NVO), passive prechamber combustion (PPC), and high energy ignition, that we also did not use in this analysis.[343]

These technologies are in various stages of development and some like PPC are in very limited production; however, we did not include them in the analysis as we do not believe these technologies will gain enough adoption during the rulemaking timeframe. We had discussed this topic in detail in the 2022 final rule and we do not think that there has been any significant development since than that would indicate that manufacturers would pursue these costly technologies.[344] If anything, manufacturers have indicated that they are willing to continue to research and develop more cost effective electrification technologies such as strong hybrids and PHEVs to meet

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not a simple substitution where the performance of a shared technology is universal. Consideration of specific vehicle requirements during the vehicle design and engineering process determine the best applicable powertrain.'').

[338] To maintain performance neutrality when sizing powertrains and selecting technologies we perform a series of simulations in Automime which are further discussed in the TSD Chapter 2.3.4 and in the CAFE Analysis Autonomie Documentation. The concept of performance neutrality is discussed in detail above in Section II.C.3, Technology Effectiveness Values, and additional reasons why we maintain a performance neutral analysis are discussed in Section II.C.6, Technology Applicability Equations and Rules.

[339] 87 FR 25796 (May 2, 2022).

[340] National Academies of Sciences, Engineering, and Medicine. 2021. Assessment of Technologies for Improving Light-Duty Vehicle Fuel Economy 2025–2035. *The National Academies Press:* Washington, DC. Section 4. Available at: *https://doi.org/10.17226/26092.* (Accessed: Feb. 28, 2024). [hereinafter 2021 NAS report].

[341] Flexible fuel vehicles (FLEX) are designed to run on gasoline or gasoline-ethanol blends of up to 85 percent ethanol.

[342] MECA Clean Mobility, Docket No. NHTSA–2023–0022–63053, at 11.

[343] ICCT, Docket No. NHTSA–2023–0022–54064, at 17.

[344] 87 FR 25784.

current and future regulations from multiple agencies.

The Alliance for Vehicle Efficiency commented that they want to see stronger support for hydrogen combustion and fuel cell vehicles in the HDPUV fleet.[345] Hydrogen powertrain technology has been in development for years and there are several roadblocks to more mainstream adoption such as system packaging, infrastructure, technology reliability and durability, and costs to name a few. While hydrogen powertrain technology has the possibility to provide improved efficiency and even with funding support from the IRA, these technologies still do not show up in the HDPUV fleet today and we do not believe the technology will gain enough market penetration in the rule making timeframe for us to include them in the pathway to compliance.

The first step in assigning engine technologies to vehicles in the LD and HDPUV analysis fleets is to use data for each manufacturer to determine which vehicle platforms share engines. Within each manufacturer's fleet, we develop and assign unique engine codes based on configuration, technologies applied, displacement, CR, and power output. While the process for engine assignments is the same between the LD and HDPUV analyses, engine codes are not shared between the two fleets, and engine technologies are not shared between the fleets, for the reasons discussed above. We also assign engine technology classes, which are codes that identify engine architecture (*e.g.,* how many cylinders the engine has, whether it is a DOHC or SOHC, and so on) to accurately account for engine costs in the analysis.

When we assign engine technologies to vehicles in the analysis fleets, we must consider the actual technologies on a manufacturer's engine and compare those technologies to the engine technologies in our analysis. We have just over 270 unique engine codes in the LD analysis fleet and just over 20 unique engine codes in the HDPUV fleet, meaning that for both analysis fleets, we must identify the technologies present on those almost 300 unique engines in the real world, and make decisions about which of our approximately 40 engine map models (and therefore engine technology on the technology tree) [346] best represents those real-world engines. When we consider how to best fit each of those 300 engines to our 40 engine technologies and engine map models, we use specific technical elements contained in manufacturer publications, press releases, vehicle benchmarking studies, technical publications, manufacturer's specification sheets, and occasionally CBI (like the specific technologies, displacement, CR, and power mentioned above), and engineering judgment. For example, in the LD analysis, an engine with a 13.0:1 CR is a good indication that an engine would be considered an HCR engine in our analysis, and some engines that achieve a slightly lower CR, *e.g.,* 12.5, may be considered an HCR engine depending on other technology on the engine, like inclusion of SGDI, increased engine displacement compared to other competitors, a high energy spark system, and/or reduction of engine parasitic losses through variable or electric oil and water pumps. Importantly, we never assign engine technologies based on one factor alone; we use data and engineering judgment to assign complex real-world engines to their corresponding engine technologies in the analysis. We believe that our initial characterization of the fleet's engine technologies reasonably captures the current state of the market while maintaining a reasonable amount of analytical complexity. Also, as a reminder, in addition to the 40 engine map models used in the Engine Paths Collection, we have over 20 additional potential powertrain technology assignments available in the Hybrid/Electric Paths Collection.

Engine technology adoption in the model is defined through a combination of technology path logic, refresh and redesign cycles, phase-in capacity limits,[347] and SKIP logic. How does technology path logic define technology adoption? Once an engine design moves to the advanced engine tree it is not allowed to move to alternate advanced engine trees. For example, any LD basic engine can adopt one of the TURBO engine technologies, but vehicles that have turbocharged engines in the analysis fleet will stay on the Turbo Engine Path to prevent unrealistic engine technology change in the short timeframe considered in the rulemaking analysis. This represents the concept of stranded capital, which as discussed above, is when manufacturers amortize research, development, and tooling expenses over many years. Besides technology path logic, which applies to all manufacturers and technologies, we place additional constraints on the adoption of VCR and HCR technologies.

VCR technology requires a complete redesign of the engine, and in the analysis fleet, only two models have incorporated this technology. VCR engines are complex, costly by design, and address many of the same efficiency losses as mainstream technologies like turbocharged downsized engines, making it unlikely that a manufacturer that has already started down an incongruent technology path would adopt VCR technology. Because of these issues, we limited adoption of the VCR engine technology to original equipment manufacturers (OEMs) that have already employed the technology and their partners. We do not believe any other manufacturers will invest to develop and market this technology in their fleet in the rulemaking time frame.

HCR engines are subject to three limitations. This is because, as we have recognized in past analyses,[348] HCR engines excel in lower power applications for lower load conditions, such as driving around a city or steady state highway driving without large payloads. Thus, their adoption is more limited than some other technologies.

First, we do not allow vehicles with 405 or more horsepower, and (to simulate parts sharing) vehicles that share engines with vehicles with 405 or more horsepower, to adopt HCR engines due to their prescribed power needs being more demanding and likely not supported by the lower power density found in HCR-based engines.[349] Because LIVC essentially reduces the engine's displacement, to make more power and keep the same levels of LIVC, manufacturers would need to increase the displacement of the engine to make the necessary power. We do not believe manufacturers will increase the displacement of their engines to accommodate HCR technology adoption because as displacement increases so does friction, pumping losses, and fuel consumption. This bears out in industry

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[345] AVE, Docket No. NHTSA–2023–0022–60213, at 6.

[346] We assign each engine code technology that most closely corresponds to an engine map; for most technologies, one box on the technology tree corresponds to one engine map that corresponds to one engine code.

[347] Although we did apply phase-in caps for this analysis, as discussed in Chapter 3.1.1 of the TSD, those phase-in caps are not binding because the model has several other less advanced technologies available to apply first at a lower cost, as well as the redesign schedules. As discussed in TSD Chapter 2.2, 100 percent of the analysis fleet will not redesign by 2023, which is the last year that phase-in caps could apply to the engine technologies discussed in this section. Please see the TSD for more information on engine phase-in caps.

[348] The discussions at 83 FR 43038 (Aug. 24, 2018), 85 FR 24383 (April 30, 2020), 86 FR 49568 and 49661 (September 3, 2021), and 87 FR 25786 and 25790 (May 2, 2022) are adopted herein by reference.

[349] Heywood, John B. Internal Combustion Engine Fundamentals. McGraw-Hill Education, 2018. Chapter 5.

trends: total engine size (or displacement) is at an all-time low, and trends show that industry focus on turbocharged downsized engine packages are leading to their much higher market penetration.[350] Separately, as seen in the analysis fleet, manufacturers generally use HCR engines in applications where the vehicle's power requirements fall significantly below our horsepower threshold. In fact, the average horsepower for the sales weighted average of vehicles in the analysis fleet that use HCR Engine Path technologies is 179 hp, demonstrating that HCR engine use has indeed been limited to lower-hp applications, and well below our 405 hp threshold. In fringe cases where a vehicle classified as having higher load requirements does have an HCR engine, it is coupled to a hybrid system.[351]

Second, to maintain a performance-neutral analysis,[352] we exclude pickup trucks and (to simulate parts sharing)[353] vehicles that share engines with pickup trucks from receiving HCR engines that are not accompanied by an electrified powertrain. In other words, pickup trucks and vehicles that share engines with pickup trucks can receive HCR-based engine technologies in the Hybridization Paths Collection of technologies. We exclude pickup trucks and vehicles that share engines with pickup trucks from receiving HCR engines that are not accompanied by an electrified powertrain because these often-heavier vehicles have higher low speed torque needs, higher base road loads, increased payload and towing requirements,[354] and have powertrains that are sized and tuned to perform this additional work above what passenger cars are required to conduct. Again, vehicle manufacturers' intended performance attributes for a vehicle—like payload and towing capability, intention for off-road use, and other attributes that affect aerodynamic drag and rolling resistance—dictate whether an HCR engine can provide a reasonable fuel economy improvement for that vehicle.[355] For example, road loads are comprised of aerodynamic loads, which include vehicle frontal area and its drag coefficient, along with tire rolling resistance that attribute to higher engine loads as vehicle speed increases.[356] We assume that a manufacturer intending to apply HCR technology to their pickup truck or vehicle that shares an engine with a pickup truck would do so in combination with an electric system to assist with the vehicle's load needs, and indeed the only manufacturer that has an HCR-like engine (in terms of how we model HCR engines in this analysis) in its pickup truck in the analysis fleet has done so.

Finally, we restrict HCR engine application for some manufacturers that are heavily performance-focused and have demonstrated a significant commitment to power dense technologies such as turbocharged downsizing.[357] When we say, ''significant commitment to power dense technologies,'' we mean that their fleets use near 100% turbocharged downsized engines. This means that no vehicle manufactured by these manufacturers can receive an HCR engine. Again, we implement this adoption feature to avoid an unquantified amount of stranded capital that would be realized if these manufacturers switched from one technology to another.

Note, however, that these adoption features only apply to vehicles that receive HCR engines that are not accompanied by an electrified powertrain. A P2 hybrid system that uses an HCR engine overcomes the low-speed torque needs using the electric motor and thus has no restrictions or SKIPs applied.

We received a limited number of comments disagreeing with the HCR restrictions we have in place,[358] [359] [360] most of which had been received in previous rulemakings. To avoid repetition, previous discussions located in prior related documents are adopted here by reference.[361]

We realize that engine technology, vehicle type, and their applications are always evolving,[362] and we agree with both the States and Cities and the Joint NGOs that the Hyundai Santa Cruz, unibody pickup truck with a 4-cylinder HCR engine, is one example of a pickup

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[350] See 2023 EPA Trends Report at 48, 78.

[351] See the Market Data Input File. As an example, the reported total system horsepower for the Ford Maverick HEV is also 191 hp, well below our 405 hp threshold. See also the Lexus LC/LS 500h: the Lexus LC/LS 500h also uses premium fuel to reach this performance level.

[352] As discussed in detail in Section III.C.3 and III.C.6 above, we maintain a performance-neutral analysis to capture only the costs and benefits of manufacturers adding fuel economy-improving technology to their vehicles in response to CAFE standards.

[353] See Section III.C.6.

[354] See SAE. Performance Requirements for Determining Tow-Vehicle Gross Combination Weight Rating and Trailer Weight Rating. Surface Vehicle Recommended Practice J2807. Issued: Apr. 2008. Revised Feb. 2020.; Reed, T. 2015. SAE J207 Tow Tests—The Standard. Motortrend. Published: Jan 16, 2015. Available at: *https://www.motortrend.com/how-to/1502-sae-j2807-tow-tests-the-standard/.* (Accessed: Feb. 28, 2024). When we say ''increased payload and towing requirements,'' we are referring to a literal defined set of requirements that manufacturers follow to ensure the manufacturer's vehicle can meet a set of performance measurements when building a tow-vehicle in order to give consumers the ability to ''cross-shop'' between different manufacturer's vehicles. As discussed in detail above in Section III.C.3 and III.C.6, we maintain a performance neutral analysis to ensure that we are only accounting for the costs and benefits of manufacturers adding technology in response to CAFE standards. This means that we will apply adoption features, like the HCR application restriction, to a vehicle that begins the analysis with specific performance measurements, like a pickup truck, where application of the specific technology would likely not allow the vehicle to meet the manufacturer's baseline performance measurements.

[355] The Joint NGOs ask NHTSA to stop quoting a 2018 Toyota comment explaining why we do not allow HCR engines in pickup trucks, stating that we are misinterpreting Toyota's purpose in explaining that the Tacoma and Camry achieve different effectiveness improvements using their HCR engines. We disagree. Toyota's comment is still relevent for this final rule as the limitations of the technology have not changed, which Toyota describes in the context of comparing why the technology provides a benefit in the Camry that we should not expect to see in the Tacoma. Note that Toyota also submitted a second set of supplemental comments (NHTSA–2018–0067–12431) that similarly confirm our understanding of the most important concept to our decision to limit HCR adoption on pickup trucks, which is that Atkinson operation is limited on pickup trucks. See Supplemental Comments of Toyota Motor North America, Inc., NHTSA–2018–0067–12376 (''Tacoma has a greater coefficient of drag from a larger frontal area, greater tire rolling resistance from larger tires with a more aggressive tread, and higher driveline losses from 4WD. Similarly, the towing, payload, and off road capability of pick-up trucks necessitate greater emphasis on engine torque and horsepower over fuel economy. This translates into engine specifications such as a larger displacement and a higher stroke-to-bore ratio. . . . Tacoma's higher road load and more severe utility requirements push engine operation more frequently to the less efficient regions of the engine map and limit the level of Atkinson operation . . . This endeavor is not a simple substitution where the performance of a shared technology is universal. Consideration of specific vehicle requirements during the vehicle design and engineering process determine the best applicable powertrain.'').

[356] 2015 NAS Report at 207–242.

[357] There are three manufacturers that met the criteria (near 100 percent turbo downsized fleet, and future hybrid systems are based on turbo-downsized engines) described and were excluded: BMW, Daimler, and Jaguar Land Rover.

[358] Joint NGOs, Docket No. NHTSA–2023–0022–61944–A2, at 13.

[359] ICCT, Docket No. NHTSA–2023–0022–54064, at 22.

[360] States and Cities, Docket No. NHTSA–2023–0022–61904–A2, at 29.

[361] 86 FR 74236 (December 29, 2021), 87 FR 25710 (May 2, 2022), Final Br. for Resp'ts, *Nat. Res. Def. Council* v. *NHTSA*, Case No. 22–1080, ECF No. 2000002 (D.C. Cir. May 19, 2023).

[362] NRDC and the Joint NGOs have disagreed with our HCR restrictions in the past and while we have made attempts to better explain our position on HCR technology and where we believe it is appropriate, our justification has remained the same. We do not believe the HCR technology is applicable to these types of vehicles because of the nature of how the technology works and removing the restrictions would present an unrealistic pathway to compliance for manufacturer that is not maximum feasible.

truck with a non-hybrid HCR engine.[363] However, we disagree that the Santa Cruz is comparable in capability to other pickup models like the Tacoma, Colorado, and Canyon, and that those pickup models should therefore be able to adopt non-hybrid HCR technology as well. Small unibody pickup trucks like the Santa Cruz and the Ford Maverick do not have the same capabilities and functionality as a body-on-frame pickup like the Toyota Tacoma.[364] We believe our current restrictions for HCR are reasonable and appropriate and we have not been presented with any new information that would suggest otherwise. Our stance on this issue has also borne out in real-world trends. Manufacturers who had the potential to use HCR technologies for high utility capable vehicles like Toyota Tacoma and Mazda CX–90 (replacing CX–9) have incorporated turbocharged engines. We do not believe HCR in its current state can provide enough fuel efficiency benefit for us to remove our current HCR restrictions; however, this by no means precludes manufacturers from developing and deploying HCR technology for future iterations of their pickup trucks.

We would also like to emphasize in response to the Joint NGOs that manufacturers do not pursue technology pathways because we model them in our analysis supporting setting CAFE and HDPUV standards. We have stated multiple times that we give an example of a low-cost compliance pathway, and no manufacturer has to comply with the pathway as we have modeled it. In fact, it is more than likely they will not follow the technology pathways we project in our standard-setting analysis because of the standard setting restrictions we have in place. Also, we do not allege that manufacturers cannot use different technologies than we model in our analysis to meet their standard, we just do not believe that manufacturers will abandon investments in one technology pathway for another, particularly with respect to HCR technology for pickup trucks and high horsepower vehicles. If we were to model unrealistic pathways to compliance, manufacturers would incur more cost, and/or see less efficiency improvement than we estimate for any given level of CAFE standards, resulting in a standard that is more stringent than maximum feasible. For this and other reasons we endeavor to model our best estimates of a low-cost pathway to compliance.

We conducted a sensitivity case in which we removed all HCR restrictions, which is titled ''Limited HCR skips'' and is described in more detail in Chapter 9.2.2.4 of the RIA. By MY 2031 in this sensitivity case, we see a 7.5% increase in HCR technology penetration, but it corresponds with an additional 3 billion gallons of gasoline and 27 million metric tons more CO2 when compared to the reference baseline. The limited HCR skips sensitivity has a total social cost that is $500 million less than the reference baseline, however, the 2.50% discount rate of the net social benefits is $100 million more than the reference baseline. This sensitivity shows that without the HCR restrictions we use more gasoline and we do not see an appreciable societal benefit. With that, and in lieu of no new developments in HCR technology we have left our HCR restrictions in place for the final rule but will continue to monitor and assess the technology for future rulemakings.[365]

How effective an engine technology is at improving a vehicle's fuel economy depends on several factors such as the vehicle's technology class and any additional technology that is being added or removed from the vehicle in conjunction with the new engine technology, as discussed in Section III.C, above. The Autonomie model's full vehicle simulation results provide most of the effectiveness values that we use as inputs to the CAFE Model. For a full discussion of the Autonomie modeling see Chapter 2.4 of the TSD and the CAFE Analysis Autonomie Documentation. The Autonomie modeling uses engine map models as the primary inputs for simulating the effects of different engine technologies.

Engine maps provide a three-dimensional representation of engine performance characteristics at each engine speed and load point across the operating range of the engine. Engine maps have the appearance of topographical maps, typically with engine speed on the horizontal axis and engine torque, power, or BMEP on the vertical axis. A third engine characteristic, such as brake-specific fuel consumption (BSFC), is displayed using contours overlaid across the speed and load map. The contours provide the values for the third characteristic in the regions of operation covered on the map. Other characteristics typically overlaid on an engine map include engine emissions, engine efficiency, and engine power. We refer to the engine maps developed to model the behavior of the engines in this analysis as engine map models.

The engine map models we use in this analysis are representative of technologies that are currently in production or are expected to be available in the rulemaking timeframe. We develop the engine map models to be representative of the performance achievable across industry for a given technology, and they are not intended to represent the performance of a single manufacturer's specific engine. We target a broadly representative performance level because the same combination of technologies produced by different manufacturers will have differences in performance, due to manufacturer-specific designs for engine hardware, control software, and emissions calibration. Accordingly, we expect that the engine maps developed for this analysis will differ from engine maps for manufacturers' specific engines. However, we intend and expect that the incremental changes in performance modeled for this analysis, due to changes in technologies or technology combinations, will be similar to the incremental changes in performance observed in manufacturers' engines for the same changes in technologies or technology combinations.

IAV developed most of the LD engine map models we use in this analysis. IAV is one of the world's leading automotive industry engineering service partners with an over 35-year history of performing research and development for powertrain components, electronics,

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[363] The Joint NGOs also give the example of the hybrid-HCR Ford Maverick as a reason why we should remove HCR restrictions from other pickup trucks; however we believe that whether an HCR can be applied to a pickup truck and whether a hybrid-HCR can be applied to a pickup truck are two separate questions. There does not seem to be a disagreement between the Joint NGOs and NHTSA that pickup trucks can adopt hybrid-HCR engines in the analysis.

[364] We have provided the specification of 2022 Ford Maverick, Toyota Tacoma, and Hyundai Santa Cruz in the docket accompying this final rule. See also Cargurus. 2023 Toyota Tacoma vs 2023 Ford Maverick: Cargurus Comparison. 2023. Available at: *https://www.cargurus.com/Cars/articles/2023-toyota-tacoma-vs-2023-ford-maverick-comparison*. (Accessed: Mar. 1, 2024). (''This is an incredibly tightly fought contest, as evidenced by the fact that CarGurus experts awarded both the 2023 Tacoma and 2023 Maverick identical overall scores of 7.3 out of 10. However, making a recommendation is easy on account of these trucks not being direct competitors. Where the Tacoma is a midsize truck that's designed for supreme offroad ability, the Maverick is a compact truck that's more at home in the city. So the choice here comes down to how much you value the Tacoma's ruggedness, extra carrying capacity and reputation for reliability over the Maverick's significantly lower price and running costs.'').

[365] See Chapter 9.2.2.4 of the Final RIA for discussion and data on the Limited HCR skips sensitivity, where we removed all HCR restrictions and compared the results to our reference case analysis.

and vehicle design.[366] Southwest Research Institute (SwRI) developed the LD diesel and HDPUV engine maps for this analysis. SwRI has been providing automotive science, technology, and engineering services for over 70 years.[367] Both IAV and SwRI developed our engine maps using the GT–POWER© Modeling tool (GT–POWER). GT–POWER is a commercially available, industry standard, engine performance simulation tool. GT–POWER can be used to predict detailed engine performance characteristics such as power, torque, airflow, volumetric efficiency, fuel consumption, turbocharger performance and matching, and pumping losses.[368]

Just like Argonne optimizes a single vehicle model in Autonomie following the addition of a singular technology to the vehicle model, our engine map models were built in GT–POWER by incrementally adding engine technology to an initial engine—built using engine test data, component test data, and manufacturers' and suppliers' technical publications—and then optimizing the engine to consider real-world constraints like heat, friction, and knock. One of the basic assumptions we make when developing our engine maps is using 87 octane gasoline because it is the most common octane rating engines are designed to operate on and it is going to be the test fuel manufacturers will have to use for EPA fuel economy testing.[369] We use a small number of initial engine configurations with well-defined BSFC maps, and then, in a very systematic and controlled process, add specific well-defined technologies to optimize a BSFC map for each unique technology combination. This could theoretically be done through engine or vehicle testing, but we would need to conduct tests on a single engine, and each configuration would require physical parts and associated engine calibrations to assess the impact of each technology configuration, which is impractical for the rulemaking analysis because of the extensive design, prototype part fabrication, development, and laboratory resources that are required to evaluate each unique configuration. We and the automotive industry use modeling as an approach to assess an array of technologies with more limited testing. Modeling offers the opportunity to isolate the effects of individual technologies by using a single or small number of initial engine configurations and incrementally adding technologies to those initial configurations. This provides a consistent reference point for the BSFC maps for each technology and for combinations of technologies that enables us to carefully identify and quantify the differences in effectiveness among technologies.

We received several comments regarding the use and benefits of high-octane and low carbon fuels in our analysis. The Missouri Corn Growers Association commented, ''[t]he proposed rule, along with NHTSA's larger policy vision around vehicles ignores the widely diverse range of powertrain and liquid fuel options that could be more widely deployed to improve energy conservation . . . .''[370] They go on to discuss the benefits of high-octane low carbon ethanol blended fuels and when combined with higher technology engines. Both the Alliance for Vehicle Efficiency[371] and the Defour Group[372] had similar comments on high octane low carbon fuels, particularly when used with HCR technology.

While we agree that a higher-octane fuel can work to improve engine fuel efficiency, we do not include it in our analysis. Our engine maps were developed with the use of 87 octane Tier 3 fuel,[373] which represents the most commonly available fuel used by consumers.[374] As we have stated previously, regulation of fuels is outside the scope of NHTSA's authority.[375] Accordingly, we made no updates to the fuel assumed used in the engine map models.

Before use in the Autonomie analysis, both IAV and SwRI validated the generated engine maps against a global database of benchmarked data, engine test data, single cylinder test data, prior modeling studies, technical studies, and information presented at conferences.[376] IAV and SwRI also validated the effectiveness values from the simulation results against detailed engine maps produced from the Argonne engine benchmarking programs, as well as published information from industry and academia.[377] This ensures reasonable representation of simulated engine technologies. Additional details and assumptions that we use in the engine map modeling are described in detail in Chapter 3.1 of the TSD and the CAFE Analysis Autonomie Model Documentation chapter titled ''Autonomie—Engine Model.''

Note that we never apply absolute BSFC levels from the engine maps to any vehicle model or configuration for the rulemaking analysis. We only use the absolute fuel economy values from the full vehicle Autonomie simulations to determine incremental effectiveness for switching from one technology to another technology. The incremental effectiveness is then applied to the absolute fuel economy or fuel consumption value of vehicles in the analysis fleet, which are based on CAFE or FE compliance data. For subsequent technology changes, we apply incremental effectiveness changes to the absolute fuel economy level of the previous technology configuration. Therefore, for a technically sound analysis, it is most important that the differences in BSFC among the engine maps be accurate, and not the absolute values of the individual engine maps.

While the fuel economy improvements for most engine technologies in the analysis are derived from the database of Autonomie full-vehicle simulation results, the analysis incorporates a handful of what we refer to as analogous effectiveness values. We use these when we do not have an engine map model for a particular

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[366] IAV Automotive Engineering. Available at: *https://www.iav.com/en*. (Accessed: Feb. 28, 2024).

[367] Southwest Research Institite. Available at: *https://www.swri.org*. (Accessed: Feb. 28, 2024).

[368] For additional information on the GT–POWER tool please see *https://www.gtisoft.com/gt-suite-applications/propulsion-systems/gt-power-engine-simulation-software*.

[369] 79 FR 23414 (April 28, 2014).

[370] Missouri Corn Growers Association, Docket No. NHTSA–2023–0022–58413 at 3.

[371] AVE, Docket No. NHTSA–2023–0022–60213, at 6.

[372] Defour Group, Docket No. NHTSA–2023–0022–59777, at 11.

[373] See TSD Chapter 3.1 for a detailed discussion on engine map model assumptions.

[374] DOE. Selecting the Right Octane Fuel. Available at: *https://www.fueleconomy.gov/feg/octane.shtml#:~:text=You%20should%20use%20the%20octane%20rating%20required%20for,others%20are%20designed%20to%20use%20higher%20octane%20fuel*. (Accessed: Mar. 27, 2024).

[375] 49 U.S.C. 32904(c).

[376] Friedrich, I. et al. 2006. Automatic Model Calibration for Engine-Process Simulation with Heat-Release Prediction. SAE Technical Paper 2006–01–0655. Available at: *https://doi.org/10.4271/2006-01-0655*. (Accessed: Feb. 28, 2024); Rezaei, R. et al. 2012. Zero-Dimensional Modeling of Combustion and Heat Release Rate in DI Diesel Engines. *SAE International Journal Of Engines*. Vol. 5(3): at 874–85. Available at: *https://doi.org/10.4271/2012-01-1065*. (Accessed: Feb. 28, 2024); Berndt, R. et al. 2015. Multistage Supercharging for Downsizing with Reduced Compression Ratio. 2015. *MTZ Worldwide*. Vol. 76: at 10–11. Available at: *https://link.springer.com/article/10.1007/s38313-015-0036-4*. (Accessed: May 31, 2023); Neukirchner, H. et al. 2014. Symbiosis of Energy Recovery and Downsizing. 2014. *MTZ Worldwide*. Vol. 75: at 4–9. Available at: *https://link.springer.com/article/10.1007/s38313-014-0219-4*. (Accessed: May 31, 2023).

[377] Bottcher, L., & Grigoriadis, P. 2019. ANL—BSFC Map Prediction Engines 22–26. IAV. Available at: *https://lindseyresearch.com/wp-content/uploads/2021/09/NHTSA-2021-0053-0002-20190430_ANL_Eng-22-26-Updated_Docket.pdf*. (Accessed: May 31, 2023); Reinhart, T. 2022. Engine Efficiency Technology Study. Final Report. SwRI Project No. 03.26457.

technology combination. To generate an analogous effectiveness value, we use data from analogous technology combinations for which we do have engine map models and conduct a pairwise comparison to generate a data set of emulated performance values for adding technology to an initial application. We only use analogous effectiveness values for four technologies that are all SOHC technologies. We determined that the effectiveness results using these analogous effectiveness values provided reasonable results. This process is discussed further in Chapter 3.1.4.2 of the TSD.

The engine technology effectiveness values for all vehicle technology classes can be found in Chapter 3.1.4. of the TSD. These values show the calculated improvement for upgrading only the listed engine technology for a given combination of other technologies. In other words, the range of effectiveness values seen for each specific technology (*e.g.,* TURBO1) represents the addition of the TURBO1 technology to every technology combination that could select the addition of TURBO1.

These values are derived from the Argonne Autonomie simulation dataset and the righthand side Y-axis shows the number of Autonomie simulations that achieve each percentage effectiveness improvement point. The dashed line and grey shading indicate the median and 1.5X interquartile range (IQR), which is a helpful metric to use to identify outliers. Comparing these histograms to the box and whisker plots presented in prior CAFE program rule documents, it is much easier to see that the number of effectiveness outliers is extremely small.

We received a comment from the International Council on Clean Transportation (ICCT) regarding the application of the engine sizing algorithm, and when it is applied in relation to vehicle road load improvement technologies. ICCT stated that, ''NHTSA continues to only downsize engines for large changes in tractive load,'' which they assume artificially increases the overall performance of the fleet. These are incorrect assumptions and chapter 2.3.4 of the TSD discusses our approach of sizing powertrains by iteratively going through both low and high speed acceleration performance loops and adjusting powertrain size as needed based on the performance neutrality requirements.[378]

We disagree with the comment implying that engine resizing is required for every technology change on a vehicle platform. We believe that this would artificially inflate effectiveness relative to cost. Manufacturers have repeatedly and consistently conveyed that the costs for redesign and the increased manufacturing complexity resulting from continual resizing engine displacement for small technology changes preclude them from doing so. NHTSA believes that it would not be reasonable or cost-effective to expect resizing powertrains for every unique combination of technologies, and even less reasonable and cost-effective for every unique combination of technologies across every vehicle model due to the extreme manufacturing complexity that would be required to do so.[379] In addition, a 2011 NAS report stated that ''[f]or small (under 5 percent [of curb weight]) changes in mass, resizing the engine may not be justified, but as the reduction in mass increases (greater than 10 percent [of curb weight]), it becomes more important for certain vehicles to resize the engine and seek secondary mass reduction opportunities.'' [380]

We also believe that ICCT's comment regarding Autonomie's engine resizing process is further addressed by Autonomie's powertrain calibration process. We do agree that the powertrain should be re-calibrated for every unique technology combination and this calibration is performed as part of the transmission shift initializer routine.[381] Autonomie runs the shift initializer routine for every unique Autonomie full vehicle model configuration and generates customized transmission shift maps. The algorithms' optimization is designed to balance minimization of energy consumption and vehicle performance.

ICCT also submitted a comment regarding the validity of the continued use of our engine map models. ICCT stated that, ''[a]lthough NHTSA scales its MY2010 hybrid Atkinson engine map to match the thermal efficiency of the MY2017 Toyota Prius, this appears to have been the only update made to the several engine maps that underpin all base and advanced engine technologies. The remaining engine maps are still primarily based on outdated engines (*e.g.,* from MY2011, 2013 and 2014 vehicles). Even with the updated hybrid engine, the newest Toyota Prius demonstrates an additional 10% improvement over the outgoing variant, due in part to improvements in engine efficiency.'' ICCT also took issue with NHTSA not using two of EPA's engine map models, and for the perceived lack of effectiveness benefit for adding cylinder deactivation technology to turbocharged and HCR engines.

We disagree with statements that our engine maps are outdated. Many of the engine maps were developed specifically to support analysis for the current rulemaking timeframe. The engine map models encompass engine technologies that are present in the analysis fleet and technologies that could be applied in the rulemaking timeframe. In many cases those engine technologies are mainstream today and will continue to be during the rulemaking timeframe. For example, the engines on some MY 2022 vehicles in the analysis fleet have technologies that were initially introduced ten or more years ago. Having engine maps representative of those technologies is important for the analysis. The most basic engine technology levels also provide a useful consistent starting point for the incremental improvements for other engine technologies. The timeframe for the testing or modeling is unimportant because time by itself doesn't impact engine map data. A given engine or model will produce the same BSFC map regardless of when testing or modeling is conducted. Simplistic discounting of engine maps based on temporal considerations alone could result in discarding useful technical information.

We also disagree with ICCT's example that our hybrid engine map models are outdated and have even been provided comments that our hybrid effectiveness values exceed reasonable thermal efficiency.[382] This is further discussed in the III.D.3 of this preamble. Finally, we responded to ICCT's criticisms that we did not employ EPA's engine map models in the 2020 final rule for MYs 2021–2026 standards, where we showed that our modeled engines provided similar incremental effectiveness values as the EPA engine map models.[383] As far as we are aware, ICCT has not provided additional information

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[378] CAFE Analysis Autonomie Documentation chapters titled ''Vehicle and Component Assumptions'' and ''Vehicle Sizing Process.''

[379] For more details, see comments and discussion in the 2020 Rulemaking Preamble Section VI.B.3.(a)(6) Performance Neutrality.

[380] National Research Council. 2011. Assessment of Fuel Economy Technologies for Light-Duty Vehicles. *The National Academies Press.* Washington, DC at 107. Available at: *https://doi.org/10.17226/12924.* (Accessed: Apr. 5, 2024) (hereinafter, 2011 NAS Report).

[381] See FRM CAFE Analysis Autonomie Documentation at Paragraph 4.4.5.2.

[382] Supplemental Comments of Toyota Motor North America, Inc., Notice of Proposed Rulemaking: Safer Affordable Fuel-Efficient Vehicles Rule, Docket No. NHTSA–2018–0067 and EPA–HQ–OAR–2018–0283.

[383] 85 FR 24397–8 (April 30, 2020).

showing that our engine map models are not reasonably similar to (if not providing a better effectiveness improvement than, in the case of the benchmarked Honda engine) EPA's engine map models.

Finally, in regard to engine effectiveness modeling, ICCT commented that ''[t]he modeled benefit of adding cylinder deactivation (DEAC) to turbocharged and HCR engines appears to be only about 25% of the benefit of adding DEAC to the base engine. While DEAC added to turbo or HCR engines will have lower pumping loss reductions than when added to base naturally aspirated engines, DEAC can still be expected to provide significant pumping loss reductions while enabling the engine to operate in a more thermally efficient region of the engine map.''

In the NPRM we gave an example of the effects of adding DEAC to a turbocharged engine and discussed more about how fuel-efficient technologies have complex interactions and the effectiveness values of technology cannot be simply added together.[384] Turbocharging and DEAC both work to reduce engine pumping losses and when working together they often provide a fuel-efficiency improvement greater then when they are working independently; however, much of these improvement happen in the same regions of engine operation where one or the other technology has a dominate effect which overshadows the benefits of the other. In other words, the benefits of the technologies are overlapping in the similar regions where the engine operates. These complex interactions among technologies are captured in our engine modeling.

The engine costs in our analysis are the product of engine DMCs, RPE, the LE, and updating to a consistent dollar year. We sourced engine DMCs from multiple sources, but primarily from the 2015 NAS report.[385] For VTG and VTGE technologies (*i.e.,* Miller Cycle), we used cost data from a FEV technology cost assessment performed for ICCT,[386] aggregated using individual component and system costs from the 2015 NAS report. We considered costs from the 2015 NAS report that referenced a Northeast States Center for a Clean Air Future (NESCCAF) 2004 report,[387] but believe the reference material from the FEV report provides more updated cost estimates for the VTG technology.

All engine technology costs start with a base engine cost, and then additional technology costs are based on cylinder and bank count and configuration; the DMC for each engine technology is a function of unit cost times either the number of cylinders or number of banks, based on how the technology is applied to the system. The total costs for all engine technologies in all MYs across all vehicle classes can be found in the Technologies Input file.

2. Transmission Paths

Transmissions transmit torque generated by the engine from the engine to the wheels. Transmissions primarily use two mechanisms to improve fuel efficiency: (1) a wider gear range, which allows the engine to operate longer at higher efficiency speed-load points; and (2) improvements in friction or shifting efficiency (*e.g.,* improved gears, bearings, seals, and other components), which reduce parasitic losses.

We only model automatic transmissions in both the LD and HDPUV analyses. The four subcategories of automatic transmissions that we model in the LD analysis include traditional automatic transmissions (AT), dual clutch transmissions (DCT), continuously variable transmissions (CVT and eCVT), and direct drive (DD) transmissions.[388] We also include high efficiency gearbox (HEG) technology improvements as options to the transmission technologies (designated as L2 or L3 in our analysis to indicate level of technology improvement).[389] There has been a significant reduction in manual transmissions over the years and they made up less than 1% of the vehicles produced in MY 2022.[390] Due to the trending decline of manual transmissions and their current low production volumes, we have removed manual transmissions from this analysis and have assigned vehicles using manual transmissions as DCTs in the analysis fleet.

We only model ATs in the HDPUV analysis because, except for DD transmissions that are only included as part of an electrified drivetrain, all HDPUV fleet analysis vehicles use ATs. In addition, from an engineering standpoint, DCTs and CVTs are not suited for HDPUV work requirements, as discussed further below. The HDPUV automatic transmissions work in the same way as the LD ATs and are labeled the same, but they are sized and mapped, in the Autonomie effectiveness modeling,[391] to account for the additional work, durability, and payload these vehicles are designed to conduct. The HDPUV transmissions are sized with larger clutch packs, higher hydraulic line pressures, different shift schedules, larger torque converter and different lock up logic, and stronger components when compared to their LD counterparts. Chapter 3.2.1 of the TSD discusses the technical specifications of the four different AT subtypes in more detail. The LD and HDPUV transmission technology paths are shown in Chapter 3.2.3 of the TSD.

To assign transmission technologies to vehicles in the analysis fleets, we identify which Autonomie transmission model is most like a vehicle's real-world transmission, considering the transmission's configuration, costs, and effectiveness. Like with engines, we use manufacturer CAFE compliance submissions and publicly available information to assign transmissions to vehicles and determine which platforms share transmissions. To link shared transmissions in a manufacturer's fleet, we use transmission codes that include information about the manufacturer, drive configuration, transmission type, and number of gears. Just like manufacturers share transmissions in multiple vehicles, the CAFE Model will treat transmissions as ''shared'' if they share a transmission code and transmission technologies will be adopted together.

While identifying an AT's gear count is fairly easy, identifying HEG levels for ATs and CVTs is more difficult. We reviewed the age of the transmission design, relative performance versus previous designs, and technologies incorporated to assign an HEG level. There are no HEG Level 3 automatic transmissions in either the LD or the

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[384] 88 FR 56167 (August 17, 2023). This example is also given in section III.C.3 of this preamble.

[385] 2015 NAS Report, Table S.2, at 7–8.

[386] Isenstadt, A. et al. 2016. Downsized, Boosted Gasoline Engines. Working Paper. ICCT 2016–22. Available at: *https://theicct.org/wp-content/uploads/2021/06/Downsized-boosted-gasoline-engines_working-paper_ICCT_27102016_1.pdf.* (Accessed: May 31, 2023).

[387] NESCCAF. 2004. Reducing Greenhouse Gas Emissions from Light-Duty Motor Vehicles. Available at: *http://www.nesccaf.org/documents/rpt040923ghglightduty.pdf.* (Accessed: May 31, 2023).

[388] Note that eCVT and DD transmissions are only coupled with electrified drivetrains and are therefore not included as a standalone transmission option on the CAFE Model's technology pathways.

[389] See 2015 NAS Report, at 191. HEG improvements for transmissions represent incremental advancements in technology that improve efficiency, such as reduced friction seals, bearings and clutches, super finishing of gearbox parts, and improved lubrication. These advancements are all aimed at reducing frictional and other parasitic loads in transmissions to improve efficiency. We consider three levels of HEG improvements in this analysis based on the National Academy of Sciences (NAS) 2015 recommendations, and CBI data.

[390] 2023 EPA Automotive Trends Report.

[391] Autonomie Input and Assumptions Description Files.

HDPUV analysis fleets. For the LD analysis we found all 7-speed, all 9-speed, all 10-speed, and some 8-speed automatic transmissions to be advanced transmissions operating at HEG Level 2 equivalence. We assigned eight-speed automatic transmissions and CVTs newly introduced for the LD market in MY 2016 and later as HEG Level 2. All other automatic transmissions are assigned to their respective transmission's initial technology level (*i.e.,* AT6, AT8, and CVT). For DCTs, the number of gears in the assignments usually match the number of gears listed by the data sources, with some exceptions (we assign dual-clutch transmissions with seven and nine gears to DCT6 and DCT8 respectively). We assigned vehicles in either the LD or HDPUV analyses fleets with a fully electric powertrain a DD transmission. We assigned any vehicle in the LD analysis fleet with a power-split hybrid (SHEVPS) powertrain an electronic continuously variable transmission (eCVT). Finally, we assigned the limited number of manual transmissions in the LD fleet as DCTs, as we did not model manual transmissions in Autonomie for this analysis.

Most transmission adoption features are instituted through technology path logic (*i.e.,* decisions about how less advanced transmissions of the same type can advance to more advanced transmissions of the same type). Technology pathways are designed to prevent ''branch hopping''—changes in transmission type that would correspond to significant changes in transmission architecture—for vehicles that are relatively advanced on a given pathway. For example, any automatic transmission with more than five gears cannot move to a dual-clutch transmission. We also prevent ''branch hopping'' as a proxy for stranded capital, which is discussed in more detail in Section III.C and Chapter 2.6 of the TSD.

For the LD analysis, the automatic transmission path precludes adoption of other transmission types once a platform progresses past an AT8. We use this restriction to avoid the significant level of stranded capital loss that could result from adopting a completely different transmission type shortly after adopting an advanced transmission, which would occur if a different transmission type were adopted after AT8 in the rulemaking timeframe. Vehicles that did not start out with AT7L2 transmissions cannot adopt that technology in the model. It is likely that other vehicles will not adopt the AT7L2 technology, as vehicles that have moved to more advanced automatic transmissions have overwhelmingly moved to 8-speed and 10-speed transmissions.[392]

CVT adoption is limited by technology path logic and is only available in the LD fleet analysis and therefore, not in the technology path for the HDPUV analysis. Vehicles that do not originate with a CVT or vehicles with multispeed transmissions beyond AT8 in the analysis fleet cannot adopt CVTs. Vehicles with multispeed transmissions greater than AT8 demonstrate increased ability to operate the engine at a highly efficient speed and load. Once on the CVT path, the platform is only allowed to apply improved CVT technologies. Due to the limitations of current CVTs, discussed in TSD Chapter 3.2, this analysis restricts the application of CVT technology on LDVs with greater than 300 lb.-ft of engine torque. This is because of the higher torque (load) demands of those vehicles and CVT torque limitations based on durability constraints. We believe the 300 lb.-ft restriction represents an increase over current levels of torque capacity that is likely to be achieved during the rule making timeframe. This restriction aligns with CVT application in the analysis fleet, in that CVTs are only witnessed on vehicles with under 280 lb.-ft of torque.[393] Additionally, this restriction is used to avoid stranded capital. Finally, the analysis allows vehicles in the analysis fleet that have DCTs to apply an improved DCT and allows vehicles with an AT5 to consider DCTs. Drivability and durability issues with some DCTs have resulted in a low relative adoption rate over the last decade. This is also broadly consistent with manufacturers' technology choices.[394] DCTs are not a selectable technology for the HDPUV analysis.

Autonomie models transmissions as a sequence of mechanical torque gains. The torque and speed are multiplied and divided, respectively, by the current ratio for the selected operating condition. Furthermore, torque losses corresponding to the torque/speed operating point are subtracted from the torque input. Torque losses are defined based on a three-dimensional efficiency lookup table that has the following inputs: input shaft rotational speed, input shaft torque, and operating condition. We populate transmission template models in Autonomie with characteristics data to model specific transmissions.[395] Characteristics data are typically tabulated data for transmission gear ratios, maps for transmission efficiency, and maps for torque converter performance, as applicable. Different transmission types require different quantities of data. The characteristics data for these models come from peer-reviewed sources, transmission and vehicle testing programs, results from simulating current and future transmission configurations, and confidential data obtained from OEMs and suppliers.[396] We model HEG improvements by modeling improvements to the efficiency map of the transmission. As an example, the AT8 model data comes from a transmission characterization study.[397] The AT8L2 has the same gear ratios as the AT8, however, we improve the gear efficiency map to represent application of the HEG level 2 technologies. The AT8L3 models the application of HEG level 3 technologies using the same principle, further improving the gear efficiency map over the AT8L2 improvements. Each transmission (15 for the LD analysis and 6 for the HDPUV analysis) is modeled in Autonomie with defined gear ratios, gear efficiencies, gear spans, and unique shift logic for the technology configuration the transmission is applied to. These transmission maps are developed to represent the gear counts and span, shift and torque converter lockup logic, and efficiencies that can be seen in the fleet, along with upcoming technology improvements, all while balancing key attributes such as drivability, fuel economy, and performance neutrality. This modeling is discussed in detail in Chapter 3.2 of the TSD and the CAFE Analysis Autonomie Documentation chapter titled ''Autonomie—Transmission Model.''

The effectiveness values for the transmission technologies, for all LD and HDPUV technology classes, are shown in Chapter 3.2.4 of the TSD. Note that the effectiveness for the AT5, eCVT, and DD technologies is not shown. The DD and eCVT transmissions do not have

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[392] 2023 EPA Automotive Trends Report, at 71, Figure 4.24.

[393] Market Data Input File.

[394] 2023 EPA Automotive Trends Report, at 77, Figure 4.24.

[395] Autonomie Input and Assumptions Description Files.

[396] Downloadable Dynamometer Database: *https://www.anl.gov/energy-systems/group/downloadable-dynamometer-database.* (Accessed: May 31, 2023).; Kim, N. et al. 2014. Advanced Automatic Transmission Model Validation Using Dynamometer Test Data. SAE 2014–01–1778. SAE World Congress: Detroit, MI.; Kim, N. et al. 2014. Development of a Model of the Dual Clutch Transmission in Autonomie and Validation With Dynamometer Test Data. *International Journal of Automotive Technologies.* Vol. 15(2): pp 263–71.

[397] CAFE Analysis Autonomie Documentation chapter titled ''Autonomie—Transmission Model.''

standalone effectiveness values because those technologies are only implemented as part of electrified powertrains. The AT5 has no effectiveness values because it is a reference-point technology against which all other transmission technologies are compared.

Our transmission DMCs come from the 2015 NAS report and studies cited therein. The LD costs are taken almost directly from the 2015 NAS report adjusted to the current dollar year or for the appropriate number of gears. We applied a 20% cost increase for HDPUV transmissions based on comparing the additional weight, torque capacity, and durability required in the HDPUV segment. Chapter 3.2 of the TSD discusses the specific 2015 NAS report costs used to generate our transmission cost estimates, and all transmission costs across all MYs can be found in CAFE Model's Technologies Input file. We have used the 2015 NAS report transmission costs for the last several LD CAFE Model analyses (since reevaluating all transmission costs for the 2020 final rule) and have received no comments or feedback on these costs. We again sought comment on our approach to estimating all transmission costs, but in particular on HDPUV transmission costs for this analysis, in addition to any publicly available data from manufacturers or reports on the cost of HDPUV transmissions. We received no comments or feedback on these costs, so we continue to use the NPRM estimates for the analysis supporting this final rule.

3. Electrification Paths

The electrification paths include a set of technologies that share common electric powertrain components, like batteries and electric motors, for certain vehicle functions that were traditionally powered by combustion engines. While all vehicles (including conventional ICE vehicles) use batteries and electric motors in some form, some component designs and powertrain architectures contribute to greater levels of electrification than others, allowing the vehicle to be less reliant on gasoline or other fuel.

Several stakeholders commented about general topics related to electrification technologies like the perceived merits or disadvantages of electric vehicles,[398] OEM investments in electric vehicles,[399] and infrastructure and supply chain considerations around electric vehicles.[400] Additional comments stated that hybrids are ''popular, cost effective'' [401] and that dozens of new electric vehicle models having reached ''twice as many as before the pandemic'' [402] with highly efficient electric vehicle technology [403] that ''is scalable and increasingly accessible.'' [404] Stakeholders stated that ''[n]early every automaker has publicly committed to transitioning model line-ups to new technologies with substantially less fuel consumption'' [405] and more electrified vehicles will enter the market ''with the goal of making these mobility options more accessible for everyone . . . offering a diverse portfolio of EVs to meet varying customer needs.'' [406] Insofar as our electrification technology penetration rates reach into the rulemaking timeframe, several other commenters stated that our *future* electrification penetration rates are not realistic due to limitations/uncertainty with battery material acquisition, manufacturing/production, and the current state of infrastructure [407] [408] [409] and are expecting PHEVs to ''play a more prominent role over the near to mid-term.'' [410] On the other hand, ICCT stated that our penetration rates of electrification technologies in the no action and action alternatives ''are reasonable and feasible.'' [411]

NHTSA thanks commenters for expressing their opinions and submitting relevant data on topics surrounding electrification technology adoption. We endeavor to reasonably model technologies that manufacturers use to respond to our standards, other government standards, and consumer preferences, and we believe that the inputs and assumptions that we selected to represent electrification technologies results in reasonable outcomes. The grounds for building the foundation to determine appropriate electrification technology effectiveness and cost values (therefore resulting in appropriate technology penetration rates) as these technologies affect the reference baseline and out years was based on numerous well-thought-out inputs and assumptions. Although time and resources limit consideration of each and every individual electrification technology, NHTSA focused on key inputs and assumptions (*e.g.,* the costs of batteries and applicability of specific electrified technologies for vehicles that do extensive work in the HDPUV fleet) to provide reasonable results for compliance pathways. While we recognize that stakeholders identified issues that they believed to be impediments to electrification technology adoption in particular fleets or market segments, we feel confident that we took the appropriate approach to determining the technologies applicable for vehicles in this analysis and that we capture many of these considerations explicitly in the analysis or qualitatively in additional technical support for this final rule. We have provided details of the inputs and assumptions in the TSD accompanying this final rule and provided more information to support our responses to comments throughout Section II and III of this preamble.

Unlike with other technologies in the analysis, including other electrification technologies, Congress placed specific limitations on how we consider the fuel economy of alternative fueled vehicles (such as PHEVs, BEVs, and FCEVs) when setting CAFE standards.[412] We implement these restrictions in the CAFE Model by using fuel economy values that assume ''charge sustaining'' (gasoline-only) PHEV operation,[413] and by restricting technologies that convert a vehicle to a BEV or a FCEV from being

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[398] *See, e.g.,* OCT, NHTSA–2023–0022–51242; ZETA, NHTSA–2023–0022–60508; ACI, NHTSA–2023–0022–50765; West Virginia AG et al., NHTSA–2023–0022–63056; Heritage Foundation, NHTSA–2023–0022–61952.

[399] Nissan, NHTSA–2023–0022–60696; GM, NHTSA–2023–0022–60686; ZETA, NHTSA–2023–0022–60508.

[400] See Section II.B for a discusssion of comments related to infrastructure and supply chain considerations.

[401] Consumer Reports, Docket No. NHTSA–2023–0022–61101–A2, at 1.

[402] ZETA, Docket No. NHTSA–2023–0022–60508, (citing their reference #294 ''Global EV Outlook 2023 Catching up with climate ambitions,'' IEA, (2023)).

[403] OCT, Docket No. NHTSA–2023–0022–51242–A1, at 4.

[404] Lucid, Docket No. NHTSA–2023–0022–50594–A1, at 2.

[405] ICCT, Docket No. NHTSA–2023–0022–54064–A1, at 8.

[406] Nissan, Docket No. NHTSA–2023–0022–60696–A1, at 3.

[407] West Virginia AG et al, Docket No. NHTSA–2023–0022–63056–A1, at 13–14.

[408] MECA, Docket No. NHTSA–2023–0022–63053–A1, at 8.

[409] AFPM, Docket No. NHTSA–2023–0022–61911–A1, at 37.

[410] Toyota, Docket No. NHTSA–2023–0022–61131–A1, at 8.

[411] ICCT, Docket No. NHTSA–2023–0022–54064–A1, at 12 (referring to ''NHTSA's estimates of battery-electric and plug-in hybrid electric vehicle penetration rates under the No Action and four ''action'' alternatives'').

[412] 49 U.S.C. 32902(h)(1), (2). In determining maximum feasible fuel economy levels, ''the Secretary of Transportation—(1) may not consider the fuel economy of dedicated automobiles; [and] (2) shall consider dual fueled automobiles to be operated only on gasoline or diesel fuel.''

[413] We estimated two sets of technology effectivness values using the Argonne full vehicle simulations: one set does not include the electrificaiton portion of PHEVs, and one set includes the combined fuel economy for both ICE operation and electric operation.

applied during ''standard-setting'' years.[414] However, there are several reasons why we must still accurately model PHEVs, BEVs, and FCEVs in the analysis; these reasons are discussed in detail throughout this preamble and, in particular, in Sections IV and VI. In brief: we must consider the existing fleet fuel economy level in calculating the maximum feasible fuel economy level that manufacturers can achieve in future years. Accurately calculating the pre-existing fleet fuel economy level is crucial because it marks the starting point for determining what further efficiency gains will be feasible during the rulemaking timeframe. As discussed in detail above and in TSD Chapter 2.2, PHEVs, BEVs, and FCEVs currently exist in manufacturer's fleets and count towards manufacturer's reference baseline compliance fuel economy values.

In addition to accurately capturing an analysis, or initial, fleet of vehicles in a given MY, we must capture a regulatory ''no action'' reference baseline in each MY; that is, the regulatory reference baseline captures what the world will be like if our rule is not adopted, to accurately capture the costs and benefits of CAFE standards. The ''no-action'' reference baseline includes our representation of the existing fleet of vehicles (*i.e.,* the LD and HDPUV analysis fleets) and (with some restrictions) our representation of manufacturer's fleets in the absence of our standards. Specifically, we assumed that in the absence of LD CAFE and HDPUV FE standards, manufacturers will produce certain BEVs to comply with California's ACC I and ACT program. We further assumed, consistent with manufacturer comments, that they will (regardless of legal requirements) produce additional BEVs consistent with the levels that would be required by California's ACC II program, were it to be granted a Clean Air Act preemption waiver. Accounting for electrified vehicles that manufacturers produced in response to state regulatory requirements or will produce for their own reasons improves the accuracy of the analysis of the costs and benefits of additional technology added to vehicles in response to CAFE standards, while adhering to the statutory prohibition against considering the fuel economy gains that could be achieved if manufacturers create new dedicated automobiles to comply with the CAFE standards.

Next, the costs and benefits of CAFE standards do not end in the MYs for which we are setting standards. Vehicles produced in standard-setting years, *e.g.,* MYs 2027 through MY 2031 in this analysis, will continue to have effects for years after they are produced as the vehicles are sold and driven. To accurately capture the costs and benefits of vehicles subject to the standards in future years, the CAFE Model projects compliance through MY 2050. Outside of the standard-setting years, we model the extent to which manufacturers could produce electrified vehicles, in order to improve the accuracy and realism of our analysis in situations where statute does not prevent us from doing so. Finally, due to NEPA requirements, we do consider the effects of electrified vehicle adoption in the CAFE Model under a ''real-world'' scenario where we lift EPCA/EISA's restrictions on our decision-making. On the basis of our NEPA analysis, we can consider the actual environmental impacts of our actions in the decision-making process, subject to EPCA's constraints.[415]

For those reasons, we must still accurately model electrified vehicles. That said, PHEVs, BEVs, and FCEVs only represent a portion of the electrified technologies that we include in the analysis. We discuss the range of modeled electrified technologies below and in detail in Chapter 3.3.1 of the TSD.

Among the simpler configurations with the fewest electrification components, micro HEV technology (SS12V) uses a 12-volt system that simply restarts the engine from a stop. Mild HEVs use a 48-volt belt integrated starter generator (BISG) system that restarts the engine from a stop and provides some regenerative braking functionality.[416] Mild HEVs are often also capable of minimal electric assist to the engine on take-off.

Strong hybrid-electric vehicles (SHEVs) have higher system voltages compared to mild hybrids with BISG systems and are capable of engine start/stop, regenerative braking, electric motor assist of the engine at higher speeds, and power demands with the ability to provide limited all-electric propulsion. Common SHEV powertrain architectures, classified by the interconnectivity of common electrified vehicle components, include both a series-parallel architecture by power-split device (SHEVPS) as well as a parallel architecture (P2).[417] P2s—although enhanced by the electrification components, including just one electric motor—remains fundamentally similar to a conventional powertrain.[418] In contrast, SHEVPS is considerably different than a conventional powertrain; SHEVPSs use two electric motors, which allows the use of a lower-power-density engine. This results in a higher potential for fuel economy improvement compared to a P2, although the SHEVPS' engine power density is lower.[419] Or, put another way, ''[a] disadvantage of the power split architecture is that when towing or driving under other real-world conditions, performance is not optimum.'' [420] In contrast, ''[o]ne of the main reasons for using parallel hybrid architecture is to enable towing and meet maximum vehicle speed targets.'' [421] This is an important distinction to understand why we allow certain types of vehicles to adopt P2 powertrains and not SHEVPS powertrains, and to understand why we include only P2 strong hybrid architectures in the HDPUV analysis. Both concepts are discussed further below.

Plug-in hybrids (PHEVs) utilize a combination gasoline-electric powertrain, like that of a SHEV, but have the ability to plug into the electric grid to recharge the battery, like that of a BEV; this contributes to all-electric mode capability in both blended and non-blended PHEVs.[422] The analysis

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[414] CAFE Model Documentation at S4.6 Technology Fuel Economy Improvements.

[415] 40 CFR 1500.1(a).

[416] See 2015 NAS Report, at 130. (''During braking, the kinetic energy of a conventional vehicle is converted into heat in the brakes and is thus lost. An electric motor/generator connected to the drivetrain can act as a generator and return a portion of the braking energy to the battery for reuse. This is called regenerative braking. Regenerative braking is most effective in urban driving and in the urban dynamometer driving schedule (UDDS) cycle, in which about 50 percent of the propulsion energy ends up in the brakes (NRC 2011, 18).'').

[417] Readers familiar with the last CAFE Model analysis may remember this category of powertrains referred to as ''SHEVP2s.'' Now that the SHEVP2 pathway has been split into three pathways based on the paired ICE technology, we refer to this broad category of technologies as ''P2s.''

[418] Kapadia, J. et al. 2017. Powersplit or Parallel—Selecting the Right Hybrid Architecture. *SAE International Journal of Alternative Power.* Vol. 6(1). Available at: *https://doi.org/10.4271/2017-01-1154.* (Accessed: May 31, 2023) (Parallel hybrids architecture typically adds the electrical system components to an existing conventional powertrain).

[419] *Id.*

[420] 2015 NAS report, at 134.

[421] Kapadia, J. et al. 2017. Powersplit or Parallel—Selecting the Right Hybrid Architecture. *SAE International Journal of Alternative Power.* Vol. 6(1). Available at: *https://doi.org/10.4271/2017-01-1154.* (Accessed: May 31, 2023).

[422] Some PHEVs operate in charge-depleting mode (*i.e.,* ''electric-only'' operation—depleting the high-voltage battery's charge) before operating in charge-sustaining mode (similar to strong hybrid operation, the gasoline and electric powertrains work together), while other (blended) PHEVs switch between charge-depleting mode and charge-sustaining mode during operation.

includes PHEVs with an all-electric range (AER) of 20 and 50 miles to encompass the range of PHEV AER in the market today. BEVs have an all-electric powertrain and use only batteries for the source of propulsion energy. BEVs with ranges of 200 to more than 350 miles are used in the analysis. Finally, FCEVs are another form of electrified vehicle that have a fully electric powertrain that uses a fuel cell system to convert hydrogen fuel into electrical energy. See TSD Chapter 3.3 for more information on every electrification technology considered in the analysis, including its acronym and a brief description. For brevity, we refer to technologies by their acronyms in this section.

Readers familiar with previous LD CAFE analyses will notice that we have increased the number of engine options available for strong hybrid-electric vehicles and plug-in hybrid-electric vehicles. As discussed above, this better represents the diversity of different hybrid architectures and engine options available in the real world for SHEVs and PHEVs, while still maintaining a reasonable level of analytical complexity. In addition, we now refer to the BEV options as BEV1, BEV2, BEV3, and BEV4, rather than by their range assignments as in the previous analysis, to accommodate using the same model code for the LD and HDPUV analyses. Note that BEV1 and BEV2 have different range assignments in the LD and HDPUV analyses; further, within the HDPUV fleet, different range assignments exist for HD pickups and HD vans.

In the CAFE Model, HDPUVs only have one SHEV option and one PHEV option.[423] The P2 architecture supports high payload and high towing requirements versus other types of hybrid architecture,[424] which are important considerations for HDPUV commercial operations. The mechanical connection between the engine, transmission, and P2 hybrid systems enables continuous power flow to be able to meet high towing weights and loads at the cost of system efficiency. We do not allow engine downsizing in this setup in so that when the battery storage system is depleted, the vehicle is still able to operate while achieving its original performance. We picked the P2 architecture for HDPUV SHEVs because, although there are currently no SHEV HDPUVs in the market on which to base a technology choice, we believe that the P2 strong hybrid architecture would more likely be picked than other architecture options, such as ones with power-split powertrains. This is because, as discussed above, the P2 architecture ''can be integrated with existing conventional powertrain systems that already meet the additional attribute requirements of these large vehicle segments.'' [425]

We only include one HDPUV PHEV option as there are no PHEVs in the HDPUV analysis fleet,[426] and there are no announcements from major manufacturers that indicate this a pathway that they will pursue in the short term (*i.e.,* the next few years).[427] We believe this is in part because PHEVs, which are essentially two separate powertrains combined, can decrease HDPUV capability by increasing the curb weight of the vehicle and reducing cargo capacity. A manufacturer's ability to use PHEVs in the HDPUV segment is highly dependent on the load requirements and the duty cycle of the vehicle. However, in the right operation, HDPUV PHEVs can have a cost-effective advantage over their conventional counterparts.[428] More specifically, there would be a larger fuel economy benefit the more the vehicle could rely on its electric operation, with partial help from the ICE; examples of duty cycles where this would be the case include short delivery applications or construction trucks that drive between work sites in the same city. Accordingly, we do think that PHEVs can be a technology option for adoption in the rulemaking timeframe. We picked a 50-mile AER for this segment based on discussions with experts at Argonne, who were also involved in DOE projects and provided guidance for this segment.[429] Additional information about each technology we considered is located in Chapter 3.3.1 of the TSD.

We sought comment on the range of electrification path technologies and received comment from stakeholders regarding electrified powertrain options for both the light-duty and HDPUV fleets.

Two commenters [430] repeatedly referenced a Roush report [431] and suggested that we should include more-capable, higher output 48-volt mild hybrid systems beyond P0 mild hybrids in our modeling, such as ''P2, P3, or P4 configurations'' [432] which offer additional benefits of ''electric power take-offs'' [433] (*i.e.,* launch assist) or ''slow-speed electric driving'' [434] on the vehicle's drive axle(s). It was also noted in comment that P2 mild hybrids mated with more advanced engine technologies have the ability to increase system efficiency.[435]

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[423] Note that while the HDPUV PHEV option is labeled ''PHEV50H'' in the technology pathway, it actually uses a basic engine. This is so the same technology pathway can be used in the LD and HDPUV CAFE Model analyses.

[424] Kapadia, J. et al. 2017. Powersplit or Parallel—Selecting the Right Hybrid Architecture. *SAE International Journal of Alternative Power,* Vol. 6(1): at 68–76. Available at: *https://doi.org/10.4271/2017-01-1154.* (Accessed: May 31, 2023). (Using current powersplit design approaches, critical attribute requirements of larger vehicle segments, including towing capability, performance and higher maximum vehicle speeds, can be difficult and in some cases impossible to meet. Further work is needed to resolve the unique challenges of adapting powersplit systems to these larger vehicle applications. Parallel architectures provide a viable alternative to powersplit for larger vehicle applications because they can be integrated with existing conventional powertrain systems that already meet the additional attribute requirements of these large vehicle segments).

[425] Kapadia, J. et al. 2017. Powersplit or Parallel—Selecting the Right Hybrid Architecture. *SAE International Journal of Alternative Power.* Vol. 6(1): at 68–76. Available at: *https://doi.org/10.4271/2017-01-1154.* (Accessed: May 31, 2023).

[426] National Renewable Energy Laboratory, Lawrence Berkeley National Laboratory, Kevala Inc., and U.S. Department of Energy. 2024. Multi-State Transportation Electrification Impact Study: Preparing the Grid for Light-, Medium-, and Heavy-Duty Electric Vehicles. DOE/EE–2818, U.S. Department of Energy, 2024.

[427] We recognize that there are some third-party companies that have converted HDPUVs into PHEVs, however, HDPUV incomplete vehicles that are retrofitted with electrification technology in the aftermarket are not regulated under this rulemaking unless the manufacturer optionally chooses to certify them as a complete vehicle. *See* 49 CFR 523.7.

[428] For the purpose of the Fuel Efficiency regulation, HDPUVs are assessed on the 2-cycle test procedure similar to the LDVs. The GVWR does not exceed 14,000 lbs in this segment. NREL. 2023. Electric and Plug-in Hybrid Electric Vehicle Publications. Available at: *https://www.nrel.gov/transportation/fleettest-publications-electric.html.* (Accessed: May 31, 2023); Birky, A. et al. 2017. Electrification Beyond Light Duty: Class 2b–3 Commercial Vehicles. Final Report. ORNL/TM–2017/744. Available at: *https://doi.org/10.2172/1427632.* (Accessed: May 31, 2023).

[429] DOE. 2023. 21st Century Truck Partnership. Vehicle Technologies Office. Available at: *https://www.energy.gov/eere/vehicles/21st-century-truck-partnership.* (Accessed: May 31, 2023); Islam, E. et al. 2022. A Comprehensive Simulation Study to Evaluate Future Vehicle Energy and Cost Reduction Potential. Final Report. ANL/ESD–22/6. Available at: *https://publications.anl.gov/anlpubs/2023/11/179337.pdf.* (Accessed: Mar. 14, 2024).

[430] ICCT, Docket No. NHTSA–2023–0022–54064; John German, Docket No. NHTSA–2023–0022–53274.

[431] Roush. 2021. Gasoline Engine Technologies for Revised 2023 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emission Standards. Final Report at 11. Sept. 24, 2021. Available at: *https://downloads.regulations.gov/EPA-HQ-OAR-2021-0208-0210/attachment_2.pdf.* (Accessed: Apr. 5, 2024).

[432] John German, Docket No. NHTSA–2023–0022–53274–A1, at 6–7.

[433] MECA, Docket No. NHTSA–2023–0022–63053–A1, at 13.

[434] ICCT, Docket No. NHTSA–2023–0022–54064–A1, at 20.

[435] ICCT, Docket No. NHTSA–2023–0022–54064–A1, at 20–21; John German, Docket No. NHTSA–2023–0022–53274–A1, at 6–7; MECA, Docket No. NHTSA–2023–0022–63053–A1, at 12–14.

We agree with the commenters that these mild hybrid configurations, such as P2 (mild) and P4, could offer better improvements compared to P0 mild hybrids. Non-P0 powertrains, however, require significant changes to the powertrain and would require a higher capacity battery—both leading to increase powertrain cost; this is similar to what we observed in past rulemakings with the (P1) CISG system, with the non-P0 mild hybrid not being a cost-effective way for manufacturers to meet standards in the rulemaking time frame. Accordingly, we did not include additional mild hybrid technology for this final rule but will consider mild hybrid advancements, such as P2 through P4, in future analysis if they become more prevalent in the U.S. market.

To extent possible, for any analyses conducted for any new rulemaking, we update as much of the technical aspects as possible with available data and time allotted. For example, we have significantly expanded our strong hybrid and plug-in hybrid offering for adopting in the rulemaking time frame, we have also updated our full vehicle modeling [436] based on the testing of Toyota RAV4 Prime,[437] Nissan Leaf,[438] and Chevy Bolt,[439] for HDPUV we worked with SwRI to develop a new engine map for P2 Hybrids.

We also received a handful of comments on technologies considered for the HDPUV analysis. ICCT commended ''NHTSA for incorporating [hybrid technologies, including PHEVs] into its modeling of the HD pickup and van fleet.'' [440] We received related supportive comment on PHEVs for HDPUV from MECA stating, ''[p]lug-in hybrids (PHEVs) can be practical for light and medium- duty trucks (*e.g.,* Class 1 through 3) that do not travel long distances or operate for long periods of time without returning to a central location.'' [441]

NHTSA appreciates the comment and MECA's technological insight. NHTSA thanks other commenters, such as ICCT, for support of our underlying assumptions and providing insight into technology trends.

Related to the electrified HDPUV fleet, AFPM stated that we ''do not distinguish between the less costly lower range BEV1 and BEV2 options, and the much more costly and virtually unavailable higher range BEV3 and BEV4 options'' for HDPUVs and that ''NHTSA should adjust its modeling to fully assess the real feasibility (and cost) of the BEVs that commercial HDPUV fleet operators really need.'' [442]

We believe that AFPM misunderstood our proposal documents. As was clear in the NPRM and outlined in TSD Chapter 3.3, there are no BEV3 or BEV4 options for HDPUVs. This is because we ensure that BEVs (and all vehicles) are modeled to meet sizing and utility (such as towing and hauling) requirements as described in Autonomie Model Documentation.[443] Additionally, we do not allow high towing capable vehicles to be fully converted BEVs as they have utility requirements that far exceed driving range of BEVs. These and other considerations of vehicle's capabilities and utility have been further discussed in the TSD Chapter 3.3. However, NHTSA disagrees with AFPM that BEV HDPUVs analyzed by NHTSA for this rule have a more limited carrying capacity than their ICE counterparts. NHTSA examined HDPUV BEV configurations in conjunction with Argonne and meetings with stakeholders prior to finalizing inputs for the CAFE Model analysis and does not believe that battery pack sizes will limit cargo capacity for HDPUVs (as opposed to what may be seen for larger MD/HD vehicles). This is especially true with the relatively lower total mileage ranges needed for HDPUV delivery vehicles, which generally operate in a more limited spatial area (as opposed again to the long-distance requirements and larger cargo area needed with larger MD/HD vehicles). To reflect these considerations, NHTSA only modeled two HDPUV range configurations for HDPUVs (termed ''BEV1'' and ''BEV2''). NHTSA disagrees that we should adjust our HDPUV modeling as we have conducted analysis based on available data on technologies and capabilities of vehicles within the fleet but appreciates AFPM's comment nonetheless; NHTSA has not made any changes to electrification pathways in the model for HDPUVs for this rulemaking.

We received comment from Alliance for Vehicle Efficiency (AVE) relating to the inclusion of FCEVs in the analysis, stating that, ''NHTSA dismisses [FCEV] chances for meaningful market penetration'' and that they encourage ''NHTSA to fully assess the fuel economy benefits that hydrogen vehicles could achieve and how these vehicles could become cost-effective solutions for manufacturers.'' [444] We disagree—not only have we assessed each powertrain technology specifically for this analysis (which includes FCEVs), our market penetration for FCEVs is aligned with market projections during the rulemaking time frame.[445]

As described in TSD Chapter 3.3, we assigned electrification technologies to vehicles in the LD and HDPUV analysis fleets using manufacturer-submitted CAFE compliance information, publicly available technical specifications, marketing brochures, articles from reputable media outlets, and data from Wards Intelligence.[446] TSD Chapter 3.3.2 shows the penetration rates of electrification technologies in the LD and HDPUV analysis fleets, respectively. Over half the LD analysis fleet has some level of electrification, with the vast majority—over 50 percent of the fleet—being micro hybrids; BEV3 (>275 miles; ≤350 miles) is the most common LD BEV technology. The HDPUV analysis fleet has only a conventional non-electrified powertrain, currently; however, the first year of HDPUV standards in this analysis is MY 2030, and we expect additional electrification technologies to be applied in the fleet before then. Like the other technology pathways, as the CAFE Model adopts electrification technologies for vehicles, more advanced levels of electrification technologies will supersede all prior levels, while certain technologies within each level are mutually exclusive. The only adoption feature applicable to micro (SS12V) and mild (BISG) hybrid technology is path logic; vehicles can only adopt micro and mild hybrid

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[436] Islam, E. S. et al. 2023. Vehicle Simulation Process to Support the Analysis for MY 2027 and Beyond CAFE and MY 2030 and Beyond HDPUV FE Standards. Report No. DOT HS 813 431. NHTSA.

[437] Iliev, S. et al. 2022. Vehicle Technology Assessment, Model Development, and Validation of a 2021 Toyota RAV4 Prime. Report No. DOT HS 813 356. NHTSA.

[438] Jehlik, F. et al. 2022. Vehicle Technology Assessment, Model Development, and Validation of a 2019 Nissan Leaf Plus. Report No. DOT HS 813 352. NHTSA.

[439] Jehlik, F. et al. 2022. Vehicle Technology Assessment, Model Development, and Validation of a 2020 Chevrolet Bolt. Report No. DOT HS 813 351. NHTSA.

[440] ICCT, Docket No. NHTSA–2023–0022–54064–A1, at 25.

[441] MECA, Docket No. NHTSA–2023–0022–63053–A1, at 14.

[442] AFPM, Docket No. NHTSA–2023–0022–61911–A2, at 88.

[443] Islam, E.S. et al. 2023. Vehicle Simulation Process to Support the Analysis for MY 2027 and Beyond CAFE and MY 2030 and Beyond HDPUV FE Standards. Report No. DOT HS 813 431. NHTSA. See the ''HDPUV Specifications'' section, at 137–38.

[444] AVE, Docket No. NHTSA–2023–0022–60213–A1, at 6.

[445] Rho Motion. EV Battery subscriptions. Available at: *https://rhomotion.com/.* (Accessed: Mar. 12, 2024).

[446] Wards Intelligence. 2022. U.S. Car and Light Truck Specifications and Prices, '22 Model Year. Available at: *https://wardsintelligence.informa.com/WI966023/US-Car-and-Light-Truck-Specifications-and-Prices-22-Model-Year.* (Accessed: May 31, 2023).

technology if the vehicle did not already have a more advanced level of electrification.

The adoption features that we apply to strong hybrid technologies include path logic, powertrain substitution, and vehicle class restrictions. Per the technology pathways, SHEVPS, P2x, P2TRBx, and the P2HCRx technologies are considered mutually exclusive. In other words, when the model applies one of these technologies, the others are immediately disabled from future application. However, all vehicles on the strong hybrid pathways can still advance to one or more of the plug-in technologies, when applicable in the modeling scenario (*i.e.,* allowed in the model).

When the model applies any strong hybrid technology to a vehicle, the transmission technology on the vehicle is superseded; regardless of the transmission originally present, P2 hybrids adopt an advanced 8-speed automatic transmission (AT8L2), and PS hybrids adopt a continuously variable transmission via power-split device (eCVT). When the model applies the P2 technology, the model can consider various engine options to pair with the P2 architecture according to existing engine path constraints—taking into account relative cost effectiveness. For SHEVPS technology, the existing engine is replaced with a full time Atkinson cycle engine.[447] For P2s, we picked the 8-speed automatic transmission to supersede the vehicle's incoming transmission technology. This is because most P2s in the market use an 8-speed automatic transmission,[448] therefore it is representative of the fleet now. We also think that 8-speed transmissions are representative of the transmissions that will continue to be used in these hybrid vehicles, as we anticipate manufacturers will continue to use these ‘‘off-the-shelf’’ transmissions based on availability and ease of incorporation in the powertrain. The eCVT (power-split device) *is* the transmission for SHEVPSs and is therefore the technology we picked to supersede the vehicle's prior transmission when adopting the SHEVPS powertrain.

SKIP logic is also used to constrain adoption for SHEVPS and PHEV20/50PS technologies. These technologies are ‘‘skipped’’ for vehicles with engines[449] that meet one of the following conditions: the engine belongs to an excluded manufacturer;[450] the engine belongs to a pickup truck (*i.e.,* the engine is on a vehicle assigned the ‘‘pickup’’ body style); the engine's peak horsepower is more than 405 hp; or if the engine is on a non-pickup vehicle but is shared with a pickup. The reasons for these conditions are similar to those for the SKIP logic that we apply to HCR engine technologies, discussed in more detail in Section III.D.1. In the real world, performance vehicles with certain powertrain configurations cannot adopt the technologies listed above and maintain vehicle performance without redesigning the entire powertrain.

It may be helpful to understand why we do not apply SKIP logic to P2s and to understand why we do apply SKIP logic to SHEVPSs. Remember the difference between P2 and SHEVPS architectures: P2 architectures are better for ‘‘larger vehicle applications because they can be integrated with existing conventional powertrain systems that already meet the additional attribute requirements’’ of large vehicle segments.[451] No SKIP logic applies to P2s because we believe that this type of electrified powertrain is sufficient to meet all of the performance requirements for all types of vehicles. Manufacturers have proven this now with vehicles like the Ford F–150 Hybrid and Toyota Tundra Hybrid.[452] In contrast, ‘‘[a] disadvantage of the power split architecture is that when towing or driving under other real-world conditions, performance is not optimum.’’[453] If we were to size (in the Autonomie simulations) the SHEVPS motors and engines to achieve not ‘‘not optimum’’ performance, the electric motors would be unrealistically large (on both a size and cost basis), and the accompanying engine would also have to be a very large displacement engine, which is not characteristic of how vehicle manufacturers apply SHEVPS ICEs in the real-world. Instead, for vehicle applications that have particular performance requirements—defined in our analysis as vehicles with engines that belong to an excluded manufacturer, engines belonging to a pickup truck or shared with a pickup truck, or the engine's peak horsepower is more than 405hp—those vehicles can adopt P2 architectures that should be able to handle the vehicle's performance requirements.

NHTSA received general comments from ICCT related to the strong hybrid technology pathway restrictions. ICCT suggested that the analysis should allow strong ‘‘hybridization on all vehicle types’’[454] in the analysis, without further elaboration on what of the above explanation they disagreed with or any technical justification for making their proposed change. To be clear, strong hybridization is allowed on all vehicle types. However, we allow different types of strong hybrid powertrains to be applied to different types of vehicles for the reasons discussed above. We believe that allowing SHEVPS and P2 powertrains to be applied subject to the base vehicle's performance requirements is a reasonable approach to maintaining a performance-neutral analysis.

LD PHEV adoption is limited only by technology path logic; however, in the HDPUV analysis, PHEV technology is not available in the model until MY 2025 for HD vans and MY 2027 for HD pickups. As discussed above, there are no PHEVs in the HDPUV analysis fleet and there are no announcements from major manufacturers that indicate this a pathway that they will pursue in the short term; that said, we do believe this is a technology that could be beneficial for very specific HDPUV applications. However, the technology is fully available for adoption by HDPUVs in the rulemaking timeframe (*i.e.,* MYs 2030 and beyond). We sought comment on this assumption, and any other information available from manufacturers or other stakeholders on the potential that original equipment manufacturers will implement PHEV technology prior to MY 2025 for HD vans, and prior to MY 2027 for HD pickups. We did not receive any specific comments on this request and so we finalized the NPRM assumptions for PHEV availability in the HDPUV fleet.

The engine and transmission technologies on a vehicle are superseded when PHEV technologies are applied. For example, the model

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[447] Designated Eng26 in the list of engine map models used in the analysis. See TSD Chapter 3.1.1.2.3 for more information.

[448] We are aware that some Hyundai vehicles use a 6-speed transmission and some Ford vehicles use a 10-speed transmission, but we have observed that the majority of P2s use an 8-speed transmission.

[449] This refers to the engine assigned to the vehicle in the 2022 analysis fleet.

[450] Excluded manufacturers included BMW, Daimler, and Jaguar Land Rover.

[451] Kapadia, J. et al. 2017. Powersplit or Parallel—Selecting the Right Hybrid Architecture. *SAE International Journal of Alternative Power.* Vol. 6(1). Available at: *https://doi.org/10.4271/2017-01-1154.* (Accessed: May 31, 2023).

[452] SAE International. 2021. 2022 Toyota Tundra: V8 Out, Twin-Turbo Hybrid Takes Over. Last revised: September 22, 2021. Available at: *https://www.sae.org/news/2021/09/2022-toyota-tundra-gains-twin-turbo-hybrid-power.* (Accessed: May 30, 2023); SAE International. 2020. Hybridization the Highlight of Ford's All-New 2021 F–150. Last revised: June 30, 2020. Available at: *https://www.sae.org/news/2020/06/2021-ford-f-150-reveal.* (Accessed: May 30, 2023).

[453] 2015 NAS report, at 134.

[454] ICCT, Docket No. NHTSA–2023–0022–54064–A1, at 18.

applies an AT8L2 transmission with all PHEV20T/50T plug-in technologies, and the model applies an eCVT transmission for all PHEV20PS/50PS and PHEV20H/50H plug-in technologies in the LD fleet and for more details on different system combinations of electrification see TSD Chapter 3.3. A vehicle adopting PHEV20PS/50PS receives a hybrid full Atkinson cycle engine, and a vehicle adopting PHEV20H/PHEV50H receives an HCR engine. For PHEV20T/50T, the vehicle receives a TURBO1 engine.

Adoption of BEVs and FCEVs is limited by both path logic and phase-in caps. They are applied as end-of-path technologies that supersede previous levels of electrification. Phase-in caps, which are defined in the CAFE Model Input Files, are percentages that represent the maximum rate of increase in penetration rate for a given technology. They are accompanied by a phase-in start year, which determines the first year the phase-in cap applies. Together, the phase-in cap and start year determine the maximum penetration rate for a given technology in a given year; the maximum penetration rate equals the phase-in cap times the number of years elapsed since the phase-in start year. Note that phase-in caps do not inherently dictate how much a technology is applied by the model. Rather, they represent how much of the fleet could have a given technology by a given year.

Because a BEV1 costs less and has slightly higher effectiveness values than other advanced electrification technologies,[455] the model will have vehicles adopt it first, until it is restricted by the phase-in cap. However, this only applies during non-standard setting years as well as when the analysis is simulated for the EIS. The standard setting simulations do not consider BEVs; thus, phase-in caps are not applicable throughout this timeframe. TSD Chapter 3.3.3 shows the phase-in caps, phase-in year, and maximum penetration rate through 2050 for BEV and FCEV technologies.

The LD BEV1 phase-in cap is informed by manufacturers' tendency to move away from low-range passenger vehicle offerings in part because of potential consumer concern with range anxiety.[456] In some cases, the advertised range on EVs may not reflect the actual real-world range in cold and hot ambient temperatures and real-world driving conditions, affecting the utility of these lower range vehicles.[457] Many manufacturers, including comments from General Motors,[458] as discussed further below, have told us that the portion of consumers willing to accept a vehicle with the lowest modeled range is small, with manufacturers targeting range values well above BEV1 range.

Furthermore, the average BEV range has steadily increased over the past decade,[459] due to battery technological progress increasing energy density as well as batteries becoming more cost effective. EPA observed in its 2023 Automotive Trends Report that ‘‘the average range of new EVs has climbed substantially. In MY 2022, the average new EV is 305 miles, or more than four times the range of an average EV in 2011.’’ [460] Based on the cited examples and basis described in this section, the maximum growth rate for LD BEV1s in the model is set accordingly low to less than 0.1 percent per year. While this rate is significantly lower than that of the other BEV technologies, the BEV1 phase-in cap allows the penetration rate of low-range BEVs to grow by a multiple of what is currently observed in the market.

For higher BEV ranges (such as that for BEV2 for both LD and HDPUVs), phase-in caps are intended to conservatively reflect potential challenges in the scalability of BEV manufacturing and implementing BEV technology on many vehicle configurations, including larger vehicles. In the short term, the penetration of BEVs is largely limited by battery material acquisition and manufacturing.[461] Incorporating battery packs with the capacity to provide greater electric range also poses its own engineering challenges. Heavy batteries and large packs may be difficult to integrate for many vehicle configurations and require vehicle structure modifications. Pickup trucks and large SUVs, in particular, require higher levels of stored energy as the number of passengers and/or payload increases, for towing and other high-torque applications. In the LD analysis, we use the LD BEV3 and BEV4 phase-in caps to reflect these transitional challenges. For HDPUV analysis, we use similar phase-in caps for the BEV1 and BEV2 to control for realities of adoption of electrified technologies in work vehicles.

Recall that BEV phase-in caps are a tool that we use in the simulations to allow the model to build higher-range BEVs (when the modeling scenario allows, as in outside of standard-setting years), because if we did not, the model would only build BEV1s, as they are the most cost-effective BEV technology. Based on the analysis provided above, we believe there is a reasonable justification for different BEV phase-in caps based on expected BEV ranges in the future. We sought comment on the BEV phase-in caps for the LD and HDPUV analyses, and we received comment from several stakeholders that asked us to reevaluate our phase-in caps for BEVs: [462] one comment from General Motors asserted a specific issue with the penetration rates of short-range BEVs, stating, ‘‘[t]he agency assumes a very large portion of the market will adopt BEVs with less than 300-mile range’’ [463] and that we should adjust ‘‘phase-in caps to recognize that 100% of the market is unlikely to adopt BEVs with 300 miles range or less.’’ [464]

We have modified the values of our phase-in caps for LD BEVs, as shown above in TSD Chapter 3.3.3, to ‘‘produce more realistic compliance pathways that project higher shares of longer-range BEVs and restrict or eliminate the projection of shorter-range BEVs in some applications;’’ [465] the broad LD

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[455] This is because BEV1 uses fewer batteries and weighs less than BEVs with greater ranges.

[456] Pratt, D. 2021. How Much Do Cold Temperatures Affect an Electric Vehicle's Driving Range? Consumer Reports. Last Revised: Dec. 19, 2021. Available at: *https://www.consumerreports.org/hybrids-evs/how-much-do-cold-temperatures-affect-an-evs-driving-range-a5751769461.* (Accessed: May 31, 2023); 2022 EPA Trends Report at 60; IEA. 2022. Trends in Electric Light-Duty Vehicles. Available at: *https://www.iea.org/reports/global-ev-outlook-2022/trends-in-electric-light-duty-vehicles.* (Accessed: May 31, 2023).

[457] AAA. 2019. AAA Electric Vehicle Range Testing. Last Revised: Feb. 2019. Available at: *https://www.aaa.com/AAA/common/AAR/files/AAA-Electric-Vehicle-Range-Testing-Report.pdf.* (Accessed: May 31, 2023).

[458] GM, Docket No. NHTSA–2023–0022–60686.

[459] DOE. 2023. Vehicle Technologies Office Fact of the Week (FOTW) #1290, In Model Year 2022, the Longest-Range EV Reached 520 Miles on a Single Charge. Published: May 15, 2023. Available at: *https://www.energy.gov/eere/vehicles/articles/fotw-1290-may-15-2023-model-year-2022-longest-range-ev-reached-520-miles.* (Accessed: Mar. 13, 2024). See also DOE, Vehicle Technologies Office. FOTW #1234, April 18, 2022: Volumetric Energy Density of Lithium-ion Batteries Increased by More than Eight Times Between 2008 and 2020. Available at: *https://www.energy.gov/eere/vehicles/articles/fotw-1234-april-18-2022-volumetric-energy-density-lithium-ion-batteries.* (Accessed: Mar. 13, 2024).

[460] 2023 EPA Automotive Trends Report, at 64.

[461] *See, e.g.,* BNEF. 2022. China's Battery Supply Chain Tops BNEF Ranking for Third Consecutive Time, with Canada a Close Second. Bloomberg New Energy Finance. Last Revised: Nov. 12, 2022. Available at: *https://about.bnef.com/blog/chinas-battery-supply-chain-tops-bnef-ranking-for-third-consecutive-time-with-canada-a-close-second/.* (Accessed: May 31, 2023).

[462] GM, Docket No. NHTSA–2023–0022–60686–A2, at 1–4; MEMA, Docket No. NHTSA–2023–0022–59204–A1, at 8; Valero, Docket No. NHTSA–2023–0022–58547–A2, at 10.

[463] GM, Docket No. NHTSA–2023–0022–60686–A2, at 3.

[464] GM, Docket No. NHTSA–2023–0022–60686–A2, at 1–8.

[465] GM, Docket No. NHTSA–2023–0022–60686–A2, at 2.

phase-in cap values adjust shorter-range BEV prevelance in the fleet.

MEMA commented that phase-in caps constrain ''the ability of the industry to pursue all compliance options'' and ''keep the production volume of BEV/FCEV technologies low.'' It was suggested that a delayed launch of some technologies (like BEVs and FCEVs, when they're more advanced) would be more practical.[466] Similarly, we also received comment from Valero on HDPUV phase-in caps for BEVs, which stated, ''NHTSA sets phase-in caps at unrealistically high values that ignore the actual penetration rates in the 2022 baseline fleet. Furthermore, NHTSA's application of fleetwide phase-in caps fails to account for the unique penetration hurdles of each tech class within the HDPUV fleet—Van 2b, Van 3, Pickup 2b, and Pickup 3.''[467]

NHTSA disagrees, in general, that phase-in caps are constraining, as these limitations are applied based on market availability, cost, and consumer acceptance in the rulemaking timeframe. Our internal research, discussions with stakeholders, and other outreach has led us to not be too optimistic on these crucial technologies, but we believe the phase-in caps represent a reasonable middle ground between allowing for the application of technology at reasonable levels. The details of phase-in caps are discussed this further in TSD Chapter 3.3.3.4.

NHTSA also disagrees with the argument that HDPUV BEV penetration from the underlying phase-in caps is unrealistic, for a few reasons. First, NHTSA's HDPUV HDPUV analysis fleet contains vehicles that span a range of model years prior to and including MY 2022 vehicles, based on the most up-to-date compliance data we had at the time of modeling. Between the earliest MY vehicle in the analysis fleet and the first MY for which we are setting standards, MY 2030, in the absence of phase-in caps, the model will pick a cost-effective pathway for compliance that manufacturers themselves may not have selected, and we want the years prior to the first analysis year to reasonably reflect reality. There are already annoucements of HDPUV BEV production and sales that are not captured in the HDPUV analysis fleet but can be observed in the analysis years.[468] Second, as discussed further in Section VI, NHTSA understands that there could be uncertatinty in looking out eight to thirteen MYs in the future; this affects new vehicle technology adoption, and so we applied some conservatatism in setting phase-in caps. Finally, when applying technologies to the HDPUVs, we considered the applications of the vehicle and what could be the limiting factors in allowing more advanced technologies to apply. For example, we maintain the engine size when a vehicle adopts PHEV technologies, and we do not allow HD pickups with work factors greater than 7500 and higher than 500 mile range to adopt BEVs, further discussed in TSD Chapters 2.3.2 and 3.3. However, we understand unique technological barriers to each of the HDPUV vehicle types, and we will continue to monitor this space and consider updating the phase-in cap modeling approach in the future.

The phase-in cap for FCEVs is assigned based on existing market share as well as historical trends in FCEV production for LDVs and HDPUVs. FCEV production share in the past five years has been extremely low and the lack of fueling infrastructure remains a limiting factor[469]—we set the phase-in cap accordingly.[470] As with BEV1, however, the phase-in cap still allows for the market share of FCEVs to grow several times over.

Autonomie determines the effectiveness of each electrified powertrain type by modeling the basic components, or building blocks, for each powertrain, and then combining the components modularly to determine the overall efficiency of the entire powertrain. The components, or building blocks, that contribute to the effectiveness of an electrified powertrain in the analysis include the vehicle's battery, electric motors, power electronics, and accessory loads. Autonomie identifies components for each electrified powertrain type and then interlinks those components to create a powertrain architecture. Autonomie then models each electrified powertrain architecture and provides an effectiveness value for each architecture. For example, Autonomie determines a BEV's overall efficiency by considering the efficiencies of the battery (including charging efficiency), the electric traction drive system (the electric machine and power electronics), and mechanical power transmission devices.[471] Or, for a PHEV, Autonomie combines a very similar set of components to model the electric portion of the hybrid powertrain and then also includes the ICE and related power for transmission components.[472] Argonne uses data from their Advanced Mobility Technology Laboratory (AMTL) to develop Autonomie's electrified powertrain models. The modeled powertrains are not intended to represent any specific manufacturer's architecture but act as surrogates predicting representative levels of effectiveness for each electrification technology. We discuss the procedures for modeling each of these sub-systems in detail in the TSD and in the CAFE Analysis Autonomie Documentation and include a brief summary below.

The fundamental components of an electrified powertrain's propulsion system—the electric motor and inverter—ultimately determine the vehicle's performance and efficiency. For this analysis, Autonomie employed a set of electric motor efficiency maps created by Oak Ridge National Laboratory (ORNL), one for a traction motor and an inverter, the other for a motor/generator and inverter.[473] Autonomie also uses test data validations from technical publications to determine the peak efficiency of BEVs and FCEVs. The electric motor efficiency maps, created from production vehicles like the 2007 Toyota Camry hybrid, 2011 Hyundai Sonata hybrid, and 2016 Chevrolet Bolt, represent electric motor efficiency as a function of torque and motor rotations per minute (RPM). These efficiency maps provide nominal and maximum speeds, as well as a maximum torque curve. Argonne uses the maps to determine the efficiency characteristics of the motors, which includes some of the losses due to power transfer through the electric machine.[474] Specifically, Argonne scales the efficiency maps, specific to powertrain type, to have total system peak efficiencies ranging from

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[466] MEMA, Docket No. NHTSA–2023–0022–59204–A1, at 8.

[467] Valero, Docket No. NHTSA–2023–0022–58547–A2, at 10.

[468] *See, e.g., https://www.ford.com/commercial-trucks/e-transit/models/cargo-van/; https://media.stellantisnorthamerica.com/newsrelease.do?id=25617&mid=1538; https://news.gm.com/newsroom.detail.html/Pages/news/us/en/2023/nov/1116-brightdrop.html.*

[469] DOE. 2023. Hydrogen Refueling Infrastructure Development. Alternative Fuels Data Center. Available at: *https://afdc.energy.gov/fuels/hydrogen_infrastructure.html.* (Accessed: May 31, 2023).

[470] 2023 EPA Automotive Trends Report, at 61, Figure 4.15.

[471] Iliev, S. et al. 2023. Vehicle Technology Assessment, Model Development, and Validation of a 2021 Toyota RAV4 Prime. Report No. DOT HS 813 356. National Highway Traffic Safety Administration.

[472] See the CAFE Analysis Autonomie Documentation.

[473] ORNL. 2008. Evaluation of the 2007 Toyota Camry Hybrid Synergy Drive System; ORNL. 2011. Annual Progress Report for the Power Electronics and Electric Machinery Program.

[474] CAFE Analysis Autonomie Documentation chapter titled ''Vehicle and Component Assumptions—Electric Machines—Electric Machine Efficiency Maps.''

96–98 percent[475]—such that their peak efficiency value corresponds to the latest state-of-the-art technologies, opposed to retaining dated system efficiencies (90–93 percent).[476]

Beyond the powertrain components, Autonomie also considers electric accessory devices that consume energy and affect overall vehicle effectiveness, such as headlights, radiator fans, wiper motors, engine control units, transmission control units, cooling systems, and safety systems. In real-world driving and operation, the electrical accessory load on the powertrain varies depending on how the driver uses certain features and the condition in which the vehicle is operating, such as for night driving or hot weather driving. However, for regulatory test cycles related to fuel economy, the electrical load is repeatable because the fuel economy regulations control for these factors. Accessory loads during test cycles do vary by powertrain type and vehicle technology class, since distinctly different powertrain components and vehicle masses will consume different amounts of energy.

The analysis fleets consist of different vehicle types with varying accessory electrical power demand. For instance, vehicles with different motor and battery sizes will require different sizes of electric cooling pumps and fans to optimally manage component temperatures. Autonomie has built-in models that can simulate these varying sub-system electrical loads. However, for this analysis, we use a fixed (by vehicle technology class and powertrain type), constant power draw to represent the effect of these accessory loads on the powertrain on the 2-cycle test. We intend and expect that fixed accessory load values will, on average, have similar impacts on effectiveness as found on actual manufacturers' systems. This process is in line with the past analyses.[477] [478] For this analysis, we aggregate electrical accessory load modeling assumptions for the different powertrain types (electrified and conventional) and technology classes (both LD and HDPUV) from data from the Draft TAR, EPA Proposed Determination,[479] data from manufacturers,[480] research and development data from DOE's Vehicle Technologies Office,[481] [482] [483] and DOT-sponsored vehicle benchmarking studies completed by Argonne's AMTL.

Certain technologies' effectiveness for reducing fuel consumption requires optimization through the appropriate sizing of the powertrain. Autonomie uses sizing control algorithms based on data collected from vehicle benchmarking,[484] and the modeled electrification components are sized based on performance neutrality considerations. This analysis iteratively minimizes the size of the powertrain components to maximize efficiency while enabling the vehicle to meet multiple performance criteria. The Autonomie simulations use a series of resizing algorithms that contain ''loops,'' such as the acceleration performance loop (0–60 mph), which automatically adjusts the size of certain powertrain components until a criterion, like the 0–60 mph acceleration time, is met. As the algorithms examine different performance or operational criteria that must be met, no single criterion can degrade; once a resizing algorithm completes, all criteria will be met, and some may be exceeded as a necessary consequence of meeting others.

Autonomie applies different powertrain sizing algorithms depending on the type of vehicle considered because different types of vehicles not only contain different powertrain components to be optimized, but they must also operate in different driving modes. While the conventional powertrain sizing algorithm must consider only the power of the engine, the more complex algorithm for electrified powertrains must simultaneously consider multiple factors, which could include the engine power, electric machine power, battery power, and battery capacity. Also, while the resizing algorithm for all vehicles must satisfy the same performance criteria, the algorithm for some electric powertrains must also allow those electrified vehicles to operate in certain driving cycles, like the US06 cycle, without assistance of the combustion engine and ensure the electric motor/generator and battery can handle the vehicle's regenerative braking power, all-electric mode operation, and intended range of travel.

To establish the effectiveness of the technology packages, Autonomie simulates the vehicles' performance on compliance test cycles.[485] For vehicles with conventional powertrains and micro hybrid powertrains, Autonomie simulates the vehicles using the 2-cycle test procedures and guidelines.[486] For mild HEVs and strong HEVs, Autonomie simulates the same 2-cycle test, with the addition of repeating the drive cycles until the final state of charge (SOC) is approximately the same as the initial SOC, a process described in SAE J1711; SAE J1711 also provides test cycle guidance for testing specific to plug-in HEVs.[487] PHEVs have a different range of modeled effectiveness during ''standard setting'' CAFE Model runs, in which the PHEV operates under a ''charge sustaining'' (gasoline-only) mode—similar to how SHEVs function—compared to ''EIS'' runs, in which the same PHEV operates under a ''charge depleting'' mode—similar to how BEVs function. For BEVs and FCEVs, Autonomie simulates vehicles performing the test cycles per guidance provided in SAE J1634.[488]

Chapters 2.4 and 3.3 of the TSD and the CAFE Analysis Autonomie Documentation chapter titled ''Test Procedure and Energy Consumption Calculations'' discuss the components

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[475] CAFE Analysis Autonomie Documentation chapter titled ''Vehicle and Component Assumptions—Electric Machines—Electric Machine Peak Efficiency Scaling.''

[476] ORNL. 2008. Evaluation of the 2007 Toyota Camry Hybrid Synergy Drive System; ORNL. 2011. Annual Progress Report for the Power Electronics and Electric Machinery Program.

[477] Technical Assessment Report (July 2016), Chapter 5.

[478] EPA Proposed Determination TSD (November 2016), at 2–270.

[479] EPA Proposed Determination TSD (November 2016), at 2–270.

[480] Alliance of Automobile Manufacturers (now Alliance for Automotive Innovation) Comments on Draft TAR, at 30.

[481] DOE. 2023. Electric Drive Systems Research and Development. Vehicle Technologies Office. Available at: *https://www.energy.gov/eere/vehicles/vehicle-technologies-office-electric-drive-systems*. (Accessed: Mar. 13, 2024).

[482] Argonne. 2023. Advanced Mobility Technology Laboratory (AMTL). Available at: *https://www.anl.gov/es/advanced-mobility-technology-laboratory*. (Accessed: Mar. 13, 2024).

[483] DOE's lab years are ten years ahead of manufacturers' potential production intent (*e.g.,* 2020 Lab Year is MY 2030).

[484] CAFE Analysis Autonomie Documentation chapter titled ''Vehicle Sizing Process—Vehicle Powertrain Sizing Algorithms—Light-Duty Vehicles—Conventional Vehicle Sizings Algorithm.''; CAFE Analysis Autonomie Documentation chapter titled ''Vehicle Sizing Process—Vehicle Powertrain Sizing Algorithms—Heavy-Duty Pickups and Vans—Conventional Vehicle Sizings Algorithm.''

[485] EPA. 2023. How Vehicles are Tested. Available at: *https://www.fueleconomy.gov/feg/how_tested.shtml*. (Accessed: May 31, 2023); EPA. 2017. EPA Test Procedures for Electric Vehicles and Plug-in Hybrids. Draft Summary. Available at: *https://www.fueleconomy.gov/feg/pdfs/EPA%20test%20procedure%20for%20EVs-PHEVs-11-14-2017.pdf*. (Accessed: May 31, 2023); CAFE Analysis Autonomie Documentation, Chapter titled 'Test Procedure and Energy Consumption Calculations.'

[486] 40 CFR part 600.

[487] PHEV testing is broken into several phases based on SAE J1711: charge-sustaining on the city and HWFET cycle, and charge-depleting on the city and HWFET cycles.

[488] SAE. 2017. Battery Electric Vehicle Energy Consumption and Range Test Procedure. SAE J1634. Available at: *https://www.sae.org/standards/content/j1634_202104/*. (Accessed: Apr. 5, 2024).

and test cycles used to model each electrified powertrain type; please refer to those chapters for more technical details on each of the modeled technologies discussed in this section.

The range of effectiveness for the electrification technologies in this analysis is a result of the interactions between the components listed above and how the modeled vehicle operates on its respective test cycle. This range of values will result in some modeled effectiveness values being close to real-world measured values, and some modeled values that will depart from measured values, depending on the level of similarity between the modeled hardware configuration and the real-world hardware and software configurations. The range of effectiveness values for the electrification technologies applied in the LD fleets are shown in TSD Figure 3–23 and Figure 3–24. Effectiveness values for electrification technologies in the HDPUV fleet are shown in TSD Figure 3–25.

Some advanced engine technologies indicate low effectiveness values when paired with hybrid architectures. The low effectiveness results from the application of advanced engines to existing P2 architectures. This effect is expected and illustrates the importance of using the full vehicle modeling to capture interactions between technologies, and capture instances of both complimentary technologies and non-complimentary technologies. When developing our hybrid engine maps, we consider the engine, engine technologies, electric motor power, and battery pack size. We calibrate our hybrid engine maps to operate in their respective hybrid architecture most effectively and to allow the electric machine to provide propulsion or assistance in regions of the engine map that are less efficient. As the model sizes the powertrain for any given application, it considers all these parameters as well as performance neutrality metrics to provide the most efficient solution. In this instance, the P2 powertrain improves fuel economy, in part, by allowing the engine to spend more time operating at efficient engine speed and load conditions. This reduces the advantage of adding advanced engine technologies, which also improve fuel economy, by broadening the range of speed and load conditions for the engine to operate at high efficiency. This redundancy in fuel savings mechanism results in a lower effectiveness when the technologies are added to each other.

We received limited comment on ways to improve our strong hybrid effectiveness modeling in the analysis. Toyota commented that our strong hybrid fuel economy improvements are ''unrealistic'' because of ''ICE and hybrid powertrains approaching the limits of diminishing returns''; Toyota also noted and disagreed with the associated rolling resistance and aerodynamic advancements producing ''such dramatic fuel efficiency gains.'' [489] Conversely, ICCT commented that our hybrid engine effectiveness is ''outdated'' and that ''NHTSA assumes no additional hybrid powertrain improvements,'' [490] mentioning ''every subsequent generation of Toyota's hybrid system significantly improves upon the prior generation's efficiency.'' [491] A similar commenter suggested that we mischaracterize ''how hybrid systems can improve engine efficiency,'' [492] also referencing a Roush report.[493]

We disagree with comment that the electrification technology represented in this analysis is ''outdated'' or ''unrealistic''—the majority of the technologies were developed specifically to support analysis for this rulemaking time frame. For example, the hybrid Atkinson engine peak thermal efficiency was updated based on 2017 Toyota Prius engine data.[494] Toyota stated that their current hybrid engines achieve 41 percent thermal efficiency, which aligns with our modeling.[495] Similarly, the electric machine peak efficiency for FCEVs and BEVs is 98 percent and based on the 2016 Chevy Bolt.[496] Specifically, Argonne scales the efficiency maps, specific to powertrain type, to have total system peak efficiencies ranging from 96–98 percent[497]—such that their peak efficiency value corresponds to the latest state-of-the-art technologies, as opposed to retaining dated system efficiencies (90–93 percent).[498] The 2016 maps scaled to peak efficiency are equivalent to (if not exceed) efficiencies seen in vehicles today and in the future. Although the base references for these technologies are from a few years ago, we have worked with Argonne to update individual inputs to reflect the latest improvements. Accordingly, we have made no changes to the electric machine efficiency maps for this final rule analysis.

We also received comments on the interaction between vehicle weights in the Autonomie modeling and vehicle weights when transitioning to BEVs in the real world. Commenters spoke to EV batteries ''creating a heavier product'' [499] and that ''some of these electric vehicles will exceed 8,500 lbs. GVWR, even though they are substitutes for comparable internal combustion engine products that certify as light trucks'' to meet customer demands.[500] Another comment from Ford requested that NHTSA reconsider the classification of MDPVs in lieu of LTs that could have weights that would force them into the HDPUV regulatory class, but still have characteristics of the light truck regulatory class.[501]

In regard to reclassifying or offering credits for MDPVs, NHTSA is bound by statute as to how these vehicles are classified for the purpose of CAFE program, and we discuss this concept further in response to these comments and other similar comments in Section VII of this preamble.

In regard to concerns that heavy vehicles could fall out of the light truck fleet into the HDPUV fleet because of the weight of batteries, and in response to comments we received on the MYs 2024–2026 analysis, for the NPRM and continued into this final rule analysis we coordinated with Argonne to

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[489] Toyota, Docket No. NHTSA–2023–0022–61131–A1, at 18.

[490] ICCT, Docket No. NHTSA–2023–0022–54064–A1, at 18.

[491] ICCT, Docket No.NHTSA–2023–0022–54064–A1, at 18.

[492] John German, Docket No. NHTSA–2023–0022–53274–A1, at 7–8.

[493] Roush report on Gasoline Engine Technologies for Improved Efficiency (Roush 2021 LDV), page 12.

[494] Atkinson Engine Peak Efficiency is based on 2017 Prius peak efficiency and scaled up to 41 percent. Autonomie Model Documentation at 138. See, ANL—All Assumptions_Summary_NPRM_022021.xlsx, ANL—Summary of Main Component Performance Assumptions_NPRM_022021.xlsx, Argonne Autonomie Model Documentation_NPRM.pdf and ANL—Data Dictionary_NPRM_022021.XLSX., which can be found in the rulemaking docket (NHTSA–2023–0022) by filtering for Supporting & Related Material.

[495] Carney, D. 2018. Toyota unveils more new gasoline ICEs with 40% thermal efficiency. SAE. April 4, 2018. Available at: *https://www.sae.org/news/2018/04/toyota-unveils-more-new-gasoline-ices-with-40-thermal-efficiency.* (Accessed Dec. 21, 2021).

[496] Momen, F. et al. 2016. Electrical propulsion system design of Chevrolet Bolt battery electric vehicle. 2016 IEEE Energy Conversion Congress and Exposition (ECCE) at 1–8. Available at:, doi: 10.1109/ECCE.2016.7855076.

[497] See CAFE Analysis Autonomie Documentation, chapter titled 'Electric Machine Peak Efficiency Scaling.'

[498] Burress, T.A. et al. 2008. Evaluation of the 2007 Toyota Camry Hybrid Synergy Drive System. Oak Ridge National Laboratory. ORNL/TM–2007/190. Available at: *https://www.osti.gov/biblio/928684/.* (Accessed: Dec. 6, 2023).; Oak Ridge National Laboratory. ORNL/TM–2011/263. Available at: *https://digital.library.unt.edu/ark:/67531/metadc845565/m2/1/high_res_d/1028161.pdf.* (Accessed: Feb. 9, 2024).

[499] ACI, Docket No. NHTSA–2023–0022–50765–A1, at 5.

[500] GM, Docket No. NHTSA–2023–0022–60686–A2, at 4.

[501] Ford, Docket No. NHTSA–2023–0022–60837–A1, at 7.

conduct the Autonomie modeling in a way that maintained the vehicle regulatory class when a vehicle was upgraded to a BEV. This process was described further in the Autonomie Model Documentation.[502] In some cases, this means some range was sacrificed, but we believe that is a tradeoff that manufacturers could make in the real world. In addition, we believe this situation where a vehicle would hop regulatory classes with the addition of a heavy battery pack only affects a very small subset of vehicles. While some manufacturers are choosing to make very large BEVs,[503] other manufacturers have chosen to focus their efforts on BEVs with smaller battery packs.[504] Our review of the MY 2022 market shows that these novelty vehicles that could toe regulatory class lines are being manufactured in lower volumes and that these moving to the HDPUV regulatory classes may have limited impact on manufacturer compliance.

When the CAFE Model turns a vehicle powered by an ICE into an electrified vehicle, it must remove the parts and costs associated with the ICE (and, potentially, the transmission) and add the costs of a battery pack and other non-battery electrification components, such as the electric motor and power inverter. To estimate battery pack costs for this analysis, we need an estimate of how much battery packs cost now (*i.e.,* a ''base year'' cost), and estimates of how that cost could reduce over time (*i.e.,* the ''learning effect.''). The general concept of learning effects is discussed in detail in Section III.C and in Chapter 2 of the TSD, while the specific learning effect we applied to battery pack costs in this analysis is discussed below. We estimate base year battery pack costs for most electrification technologies using BatPaC, which is an Argonne model designed to calculate the cost of EV battery packs.

Traditionally, a user would use BatPaC to cost a battery pack for a single vehicle, and the user would vary factors such as battery cell chemistry, battery power and energy, battery pack interconnectivity configurations, battery pack production volumes, and/or charging constraints, just to name a few, to see how those factors would increase or decrease the cost of the battery pack. However, several hundreds of thousands of simulated vehicles in our analysis have electrified powertrains, meaning that we would have to run individual BatPaC simulations for each full vehicle simulation that requires a battery pack. This would have been computationally intensive and impractical. Instead, Argonne staff builds ''lookup tables'' with BatPaC that provide battery pack manufacturing costs, battery pack weights, and battery pack cell capacities for vehicles with varying power requirements modeled in our large-scale simulation runs.

Just like with other vehicle technologies, the specifications of different vehicle manufacturer's battery packs are extremely diverse. We, therefore, endeavored to develop battery pack costs that reasonably encompass the cost of battery packs for vehicles in each technology class.

In conjunction with our partners at Argonne working on the CAFE analysis Autonomie modeling, we referenced BEV outlook reports,[505] vehicle teardown reports,[506] and stakeholder discussions [507] to determine common battery pack chemistries for each modeled electrification technology. The CAFE Analysis Autonomie Documentation chapter titled ''Battery Performance and Cost Model—BatPaC Examples from Existing Vehicles in the Market'' includes more detail about the reports referenced for this analysis.[508] For mild hybrids, we used the LFP–G [509] chemistry because power and energy requirements for mild hybrids are very low, the charge and discharge cycles (or need for increased battery cycle life) are high, and the battery raw materials are much less expensive than a nickel manganese cobalt (NMC)-based cell chemistry. We used NMC622–G [510] for all other electrified vehicle technology base (MY 2022) battery pack cost calculations. While we made this decision at the time of modeling based on the best available information, while also considering feedback on prior rules,[511] more recent data affirms that BEV batteries using NMC622 cathode chemistries are still a significant part of the market.[512] We recognize there is ongoing research and development with battery cathode chemistries that may have the potential to reduce costs and increase battery capacity.[513] In

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[502] See Vehicle Technical Specification in Autonomie Model Documentation.

[503] GM Newsroom. An Exclusive Special Edition: 2024 GMC HUMMER EV Omega Edition Has Landed. Available at: *https://news.gm.com/newsroom.detail.html/content/Pages/news/us/en/2023/may/0505-hummer.html.* (Accesed Mar. 28, 2024).

[504] Martinez, M. Ford delays 3-row EVs as focus shifts to smaller, affordable products, sources say, Auto News (March 19, 2024). Available at: *https://www.autonews.com/cars-concepts/ford-shifts-3-row-evs-smaller-affordable-models.* (Accessed: Apr. 5, 2024).

[505] Rho Motion. EV Battery subscriptions. Available at: *https://rhomotion.com/.* (Accessed: Mar. 12, 2024); BNEF. 2023. Electric Vehicle Outlook 2023. Available at: *https://about.bnef.com/electric-vehicle-outlook/.* (Accessed: May 31, 2023); Benchmark Mineral Intelligence. Cathode, Anode, and Gigafactories subscriptions. Available at: *https://benchmarkminerals.com/.* (Accessed: Mar. 12, 2024); Bibra, E. et al. 2022. Global EV Outlook 2022—Securing Supplies For an Electric Future. International Energy Agency. Available at: *https://iea.blob.core.windows.net/assets/ad8fb04c-4f75-42fc-973a-6e54c8a4449a/GlobalElectricVehicleOutlook2022.pdf.* (Accessed: May 31, 2023).

[506] Hummel, P. et al. 2017. UBS Evidence Lab Electric Car Teardown—Disruption Ahead? UBS. Available at: *https://neo.ubs.com/shared/d1ZTxnvF2k.* (Accessed: May 31, 2023); A2Mac1: Automotive Benchmarking. (Proprietary data). Available at: *https://portal.a2mac1.com/.* (Accessed: May 31, 2023).

[507] See Ex Parte Meetings Prior to Publication of the Corporate Average Fuel Economy Standards for Passenger Cars and Light Trucks for Model Years 2027–2032 and Fuel Efficiency Standards for Heavy-Duty Pickup Trucks and Vans for Model Years 2030–2035 Notice of Proposed Rulemaking memorandum, which can be found in the rulemaking Docket (NHTSA–2023–0022) by filtering for References and Supporting Material.

[508] CAFE Analysis Autonomie Documentation chapter titled ''Battery Performance and Cost Model—BatPac Examples from Existing Vehicles in the Market.''

[509] Lithium Iron Phosphate ($LiFePO_4$) cathode and Graphite anode.

[510] Lithium Nickel Manganese Cobalt Oxide ($LiNiMnCoO_2$) cathode and Graphite anode.

[511] Stakeholders had commented on both the 2020 and 2022 final rules that batteries using NMC811 chemistry had either recently come into or were imminently coming into the market, and therefore we should have selected NMC811 as the appropriate chemistry for modeling battery pack costs.

[512] Rho Motion. Seminar Series Live, Q1 2023—Seminar Recordings. Emerging Battery Technology Forum. February 7, 2023. Available at: *https://rhomotion.com/rho-motion-seminar-series-live-q1-2023-seminar-recordings.* (Accessed: May 31, 2023). More specifically, the monthly weighted average global EV battery cathode chemistry across all vehicle classes shows that 19% use NMC622 and 20% use NMC811+, representing a fairly even split. Even though we considered domestic battery production rather than global battery production for the analysis supporting this final rule, NMC622 is still prevalent even at a global level. Note that this seminar video is no longer publicly available to non-subscribers. See Rho Motion. EV Battery subscriptions. Available at: *https://rhomotion.com/* . (Accessed: Mar. 12, 2024); Benchmark Mineral Intelligence. Lithium-ion Batteries & Cathode monthly & quarterly subscriptions. Available at: *https://benchmarkminerals.com/.* (Accessed: Mar. 12, 2024).

[513] Slowik, P. et. al. 2022. Assessment of Light-Duty Electric Vehicle Costs and Consumer Benefits in the United States in the 2022–2035 Time Frame. International Council on Clean Transportation. Available at: *https://theicct.org/wp-content/uploads/2022/10/ev-cost-benefits-2035-oct22.pdf.* (Accessed: May 31, 2023); Batteries News. 2022. Solid-State NASA Battery Beats The Model Y 4680 Pack at Energy Density by Stacking all Cells in One Case. Last revised: Oct. 20, 2022. Available at: *https://batteriesnews.com/solid-state-nasa-battery-beats-model-y-4680-pack-energy-density-stacking-cells-one-case/.* (Accessed: May 31, 2023); Sagoff, J. 2023. Scientists Develop More Humane, Environmentally Friendly Battery Material. ANL. Available at: *https://www.anl.gov/article/scientists-develop-more-humane-environmentally-friendly-battery-material.* (Accessed: May 31, 2023); IEA. 2023. Global EV Outlook 2023. Available at: *https://www.iea.org/reports/global-ev-outlook-2023.* (Accessed: May 31, 2023); Motavalli, J. 2023. SAE International. Can solid-state batteries

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particular, we are aware of a recent shift by manufacturers to transition to lithium iron phosphate (LFP) chemistry-based battery packs as prices for materials used in battery cells fluctuate (see additional discussion below); however, we believe that based on available data,[514] NMC622 is more representative for our MY 2022 base year battery costs than LFP, and any additional cost reductions from manufacturers switching to LFP chemistry-based battery packs in years beyond 2022 are accounted for in our battery cost learning effects. The learning effects estimate potential cost savings for *future* battery advancements (a learning rate applied to the battery pack DMC), this final rule includes a dynamic NMC/LFP cathode mix over each future model year, as discussed in more detail below. As discussed above, the battery chemistry we use is intended to reasonably represent what is used in the MY 2022 U.S. fleet, the DMC base year for our BatPaC calculations.

We also looked at vehicle sales volumes in MY 2022 to determine a reasonable base production volume assumption.[515] In practice, a single battery plant can produce packs using different cell chemistries with different power and energy specifications, as well as battery pack constructions with varying battery pack designs—different cell interconnectivities (to alter overall pack power end energy) and thermal management strategies—for the same base chemistry. However, in BatPaC, a battery plant is assumed to manufacture and assemble a specific battery pack design, and all cost estimates are based on one single battery plant manufacturing only that specific battery pack. For example, if a manufacturer has more than one BEV in its vehicle lineup and each uses a specific battery pack design, a BatPaC user would include manufacturing volume assumptions for each design separately to represent each plant producing each specific battery pack. As a consequence, we examined battery pack designs for vehicles sold in MY 2022 to determine a reasonable manufacturing plant production volume assumption. We considered each assembly line designed for a specific battery pack and for a specific BEV as an individual battery plant. Since battery technologies and production are still evolving, it is likely to be some time before battery cells can be treated as commodity where the specific numbers of cells are used for varying battery pack applications and all other metrics remain the same.

Similar to previous rulemakings, we used BEV sales as a starting point to analyze potential base modeled battery manufacturing plant production volume assumptions. Since actual production data for specific battery manufacturing plants are extremely hard to obtain and the battery cell manufacturer is not always the battery pack manufacturer,[516] we calculated an average production volume per manufacturer metric to approximate BEV production volumes for this analysis. This metric was calculated by taking an average of all BEV battery energies reported in vehicle manufacturer's PMY 2022 reports[517] and dividing by the averaged sales-weighted energy per-vehicle; the resulting volume was then rounded to the nearest 5,000. Manufacturers are not required to report gross battery pack sizes for the PMY report, so we estimated pack size for each vehicle based on publicly available data, like manufacturer's announced specifications. This process was repeated for all other electrified vehicle technologies. We believe this gave us a reasonable base year plant production volume—especially in the absence of actual production data—since the PMY data from manufacturers already includes accurate related data, such as vehicle model and estimated sales information metrics.[518] Our final battery manufacturing plant production volume assumptions for different electrification technologies are as follows: mild hybrid and strong hybrids are manufactured assuming 200,000 packs, PHEVs are manufactured assuming 20,000 packs, and BEVs are manufactured assuming 60,000 packs.

We believe it was reasonable to consider U.S. sales for purposes of this calculation rather than global sales based on the best available data we had at the time of modeling and based on our understanding of how manufacturers design BEVs for particular markets.[519][520] A manufacturer may have previously sold the same vehicle with different battery packs in two different markets, but as the outlook for battery materials and global economic events dynamically shift, manufacturers could take advantage of significant design overlap and other synergies like from vertical integration to introduce lower-cost battery packs in markets that it previously perceived had different design requirements.[521] To the extent that manufacturers' costs are based more closely on global volumes of battery packs produced, our base year battery pack *production volume* assumption could potentially be conservative; however, as discussed further below, our base year MY 2022 battery pack *costs* fall well within the range of reasonable estimates based on 2023 data. We sought comment on our

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commercialize by 2030? Nov. 9, 2023. Available at: *https://www.sae.org/news/2023/11/solid-state-battery-status.* (Accessed: Mar. 12, 2024).

[514] Rho Motion. EV Battery subscriptions. Available at: *https://rhomotion.com/.* (Accessed: Mar. 12, 2024); IEA. 2023. Global EV Outlook 2023.. Available at *https://www.iea.org/reports/global-ev-outlook-2023.* (Accessed: Mar. 12, 2024). As of IEA's 2023 Global EV Outlook report, ''around 95% of the LFP batteries for electric LDVs went to vehicles produced in China, and BYD [a Chinese EV manufacturer] alone represents 50% of demand. Tesla accounted for 15%, and the share of LFP batteries used by Tesla increased from 20% in 2021 to 30% in 2022. Around 85% of the cars with LFP batteries manufactured by Tesla were manufactured in China, with the remainder being manufactured in the United States with cells imported from China. In total, only around 3% of electric cars with LFP batteries were manufactured in the United States in 2022.'' This is not to say that as of 2022 there were no current production or use of vehicle battery packs with LFP-based chemistries in the U.S., but rather that based on available data, we are more certain that NMC622 was a reasonable chemistry selection for our 2022 base year battery costs.

[515] See Chapter 2.2.1.1 of the TSD for more information on data we use for MY 2022 sales volumes.

[516] Lithium-Ion Battery Supply Chain for E-Drive Vehicles in the United States: 2010–2020, ANL/ESD–21/3; Gohlke, D. et al. 2024. Quantification of Commercially Planned Battery Component Supply in North America through 2035. Final Report. ANL–24/14. Available at: *https://publications.anl.gov/anlpubs/2024/03/187735.pdf.* (Accessed: Apr. 5, 2024).

[517] 49 CFR 537.7.

[518] NHTSA used publicly available range and pack size information and linked the information to vehicle models.

[519] As an example, a manufacturer might design a BEV to suit local or regional duty cycles (*i.e.,* how the vehicle is driven day-to-day) due to local geography and climate, customer preferences, affordability, supply constraints, and local laws. This is one factor that goes into chemistry selection, as different battery chemistries affect a vehicle's range capability, rate of degradation, and overall vehicle mass.

[520] Rho Motion. EV Battery subscriptions. Available at: *https://rhomotion.com/.* (Accessed: Mar. 12, 2024).

[521] As an example, some U.S. Tesla Model 3 and Model Y battery packs use a nickel cobalt aluminum (Lithium Nickel Manganese Cobalt Aluminum Oxide cathode with Graphite anode, commonly abbreviated as NCA)-based cell, while the same vehicles for sale in China use LFP-based packs. However, Tesla has introduced LFP-based battery packs to some Model 3 vehicles sold in the U.S., showing how manufacturers can take advantage of experience in other markets to introduce different battery technology in the United States. See Electric Vehicle Database. 2023. Tesla Model 3 Standard Range Plus LFP. Available at: *https://ev-database.uk/car/1320/Tesla-Model-3-Standard-Range-Plus-LFP.* (Accessed: May 31, 2023). See the Tesla Model 3 Owner's Manual for additional considerations regarding LFP-based batteries, at *https://www.tesla.com/ownersmanual/model3/en_jo/GUID-7FE78D73-0A17-47C4-B21B-54F641FFAEF4.html.*

approach to calculating base year cost estimates, and we also sought comment from manufacturers and other stakeholders on how vehicle and battery manufacturers take advantage of design overlap across markets to maintain cost reduction progress in battery technology; we did not receive comment on either of these particular issues.

As mentioned above, our BatPaC lookup tables provide $/kWh battery pack costs based on vehicle power and energy requirements. As an example, a midsized SUV with mid-level road load reduction technologies might require a 110–120kWh energy and 200–210kW power battery pack. From our base year BatPaC cost estimates, that vehicle might have a battery pack that costs around $123/kWh. Note that the total cost of a battery pack increases the higher the power/energy requirements, however the cost per kWh decreases. This represents the cost of hardware that is needed in all battery packs but is deferred across more kW/kWh in larger packs, which reduces the per kW/kWh cost. Table 3–78 in TSD Chapter 3.3.5 shows an example of the BatPaC-based lookup tables for the BEV3 SUV through pickup technology classes.

Note that the values in the table above should *not* be considered the total battery $/kWh costs that are used for vehicles in the analysis in future MYs. As detailed below, battery costs are also projected to decrease over time as manufacturers improve production processes, shift battery chemistries, and make other technological advancements. In addition, select modeled tax credits further reduce our estimated costs; additional discussion of those tax credits is located throughout this preamble, TSD Chapter 2.3, and the FRIA Chapters 8 and 9.

The CAFE Analysis Autonomie Documentation details other specific assumptions that Argonne used to simulate battery packs and their associated base year costs for the full vehicle simulation modeling, including updates to the battery management unit costs, and the range of power and energy requirements used to bound the lookup tables.[522] Please refer to the CAFE Analysis Autonomie Documentation and Chapter 3.3 of the TSD for further information about how we used BatPaC to estimate base year battery costs. The full range of BatPaC-generated battery DMCs is located in the file ANL—Summary of Main Component Performance Assumptions_NPRM_2206. Note again that these charts represent the DMC using a dollar per kW/kWh metric; battery absolute costs used in the analysis by technology key can be found in the CAFE Model Battery Costs File.

Our method of estimating future battery costs has three fundamental components: (1) an estimate of MY 2022 battery pack costs (*i.e.,* our base year costs generated in the BatPaC model (version 5.0, March 2022 release) to estimate battery pack costs for specific vehicles, depending on factors such as pack size and power requirements, discussed above), (2) future learning rates estimated using a learning curve,[523] and (3) the effect of changes in the cost of key minerals on battery pack costs, which are discussed below.

For the proposal, NHTSA estimated learning rates using a study by Mauler et al.,[524] in which the authors fit a central tendency curve to 237 published estimates of lithium-ion battery costs. To reflect the combination of fluctuating mineral costs and an increase in demand in the near-term, NHTSA also held the battery pack cost learning curve constant between MYs 2022 and 2025. We explained that this was a conservative assumption that was also employed by EPA in their proposed rule (and now final rule, as discussed further below) for light duty vehicles and medium duty vehicles beginning in MY 2027 at NPRM Preamble Section II.D.3 and Draft Technical Support Document Chapter 3.3.5.3.1. The assumption reflected increased lithium costs since 2020 that were not expected to decline appreciably to circa 2020 levels until additional capacity (mining, materials processing, and cell production) comes on-line,[525] although prices had already fallen from 2022 highs at the time the NPRM was published. NHTSA stated that a continuation of high prices for a few years followed by a decrease to near previous levels is reasonable because world lithium resources are more than sufficient to supply a global EV market and higher prices should continue to induce investment in lithium mining and refining.[526] [527] NHTSA stated that the resulting battery cost estimates provided a reasonable representation of potential future costs across the industry, based on the information available to us at the time of the analysis for this proposal was completed. We also included a summary of current and future battery cost estimates from other government agencies, consulting firms, and manufacturers to both highlight the uncertainties in estimating future battery costs and to show that our estimated costs fell reasonably within the range of projections.[528] NHTSA also examined several battery sensitivity cases that showed examples of how changing different battery pack assumptions could change battery pack costs over time. NHTSA also reminded commenters that because of NHTSA's inability to consider manufacturers building BEVs in response to CAFE standards during standard-setting years, net social costs and benefits do not change significantly between battery cost sensitivity cases, and similarly would not change significantly if much lower battery costs were used.

NHTSA also noted ongoing conversations with DOE and EPA on battery costs,[529] and sought comment on a variety of topics surrounding future battery costs. We sought comment in

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[522] CAFE Analysis Autonomie Documentation chapter titled ''Battery Performance and Cost Model—Use of BatPac in Autonomie.''

[523] See Wene, C. 2000. Experience Curves for Energy Technology Policy. International Energy Agency, OECD. Paris. Available at: *https://doi.org/10.1787/9789264182165-en.* (Accessed: May 31, 2023). The concept of a learning curve was initially developed to describe cost reduction due to improvements in manufacturing processes from knowledge gained through experience in production; however, it has since been recognized that other factors make important contributions to cost reductions associated with cumulative production. We discuss this concept further, in Section II.C.

[524] Mauler, L. et al.. Battery Cost Forecasting: A Review Of Methods And Results With An Outlook To 2050. Energy and Environmental Science: at 4712–4739.

[525] Trading Economics. 2023. Lithium. Available at: *https://tradingeconomics.com/commodity/lithium.* (Accessed: May 31, 2023).

[526] Barlock, T.A. et al. February 2024. Securing Critical Materials for the U.S. Electric Vehicle Industry. ANL–24/06. Final Report. Available at: *https://publications.anl.gov/anlpubs/2024/03/187907.pdf.* (Accessed: Apr. 5, 2024); U.S. Geological Survey. 2023. Lithium Statistics and Information. Available at: *https://www.usgs.gov/centers/national-minerals-information-center/lithium-statistics-and-information.* (Accessed: May 31, 2023).

[527] According to 2021 estimates from the U.S. Geological Survey (USGS), global lithium resources are currently four times as large as global reserves. Lithium resources and reserves have both grown over time as production has increased. These resources and reserves, however, are not evenly distributed geographically. Bolivia (24%), Argentina (22%), Chile (11%), the United States (10%), Australia (8%) and China (6%) together hold four-fifths of the world's lithium resources. USGS defines ''resources'' as a concentration of naturally occurring solid, liquid, or gaseous material in or on the Earth's crust in such form and amount that economic extraction of a commodity from the concentration is currently or potentially feasible. USGS defines ''reserves'' as the part of the reserve base that could be economically extracted or produced at the time of determination. USGS defines ''reserve base'' as the part of an identified resource that meets specified minimum physical and chemical criteria related to mining and production practices, including those for grade, quaality, thickness, and depth. See *https://pubs.usgs.gov/periodicals/mcs2021/mcs2021-lithium.pdf* for USGS's 2021 estimates and *https://pubs.usgs.gov/periodicals/mcs2022/mcs2022-appendixes.pdf* for USGS definitions.

[528] 88 FR 56219–20 (Aug. 17, 2023).

[529] 88 FR 56222 (Aug. 17, 2023).

particular from vehicle and battery manufacturers on any additional data they could submit (preferably publicly) to further the conversation about battery pack costs in the later part of this decade through the early 2030s. In addition, we sought comment on all aspects of our methodology for modeling base year and future year battery pack costs, and welcomed data or other information that could inform our approach for the final rulemaking. We specifically sought comment on how the performance metrics may change in response to shifts in chemistries used in vehicle models driven by global policies affecting battery supply chain development, total global production and associated learning rates, and related sensitivity analyses. Finally, NHTSA also recognized the uncertainty in critical minerals prices into the near future and sought comment on representation of mineral costs in the learning curve, and any other feedback relevant to incorporating these considerations into our modeling framework.

We received comments from several stakeholders regarding general trends and forecasts in battery costs, our battery cost curves, and underlying battery cost assumptions. Some stakeholders cited outside sources they said supported our battery cost values, and other stakeholders cited outside sources they claimed showed our battery cost values were too low. ZETA stated generally that, ''[o]verall, the cost of lithium-ion batteries declined substantially between 2008 and 2022, down to $153 per kWh,'' [530] citing DOE's estimates [531] as well as Benchmark Minerals information. ICCT commented that ''there is evidence available to support lower BEV costs than NHTSA has modeled'' and that automakers ''are investing heavily in BEV R&D and manufacturing capacity and are achieving higher production volumes with more advanced technologies at lower costs.'' [532] ICCT continued to cite their research from 2022,[533] also referenced by NHTSA in the NPRM, stating, ''[c]ontinued technological advancements and increased battery production volumes mean that pack-level battery costs are expected to decline to about $105/kWh by 2025 and $74/kWh by 2030.''

NHTSA appreciates the extensive data on declining EV battery costs provided by ZETA, and we believe that the provided data and lines up with our estimates from the NPRM and now this final rule reasonably well. NHTSA agrees with ICCT that there is evidence to support lower BEV costs than what was modeled in the NPRM. NHTSA has since, in collaboration with DOE/Argonne and EPA, modified the battery learning curve used in this analysis, which ultimately reflects lower future battery costs compared to the NPRM. The methodology that NHTSA employed is discussed further below and in TSD Chapter 3.3.

On the other hand, comments from POET highlighted a BNEF reference from 2022, stating that our optimistic learning curve is contradictory to BNEF's analysis [534]—citing ''demand continues to grow, battery producers and automakers are scrambling to secure key metals such as lithium and nickel, battling high prices and tight supply'' [535] and stating we should ''not rely on battery back [sic] learning curves, which have significant uncertainties.'' [536] Additional commenters stated that battery cost reduction curves have flattened and costs ''rose 7 percent in 2022'' [537] with AFPM stating further, ''BEV makers will need to increase prices by 25% to account for rising battery prices,'' citing a March 2022 Bloomberg article on Morgan Stanley projections; [538] Valero commented that some ''forecasters have made naïve predictions that the cost declines will continue,'' [539] with Clean Fuels Development Coalition in agreement stating that the decline in battery costs ''isn't realistic.'' [540] Valero commented that our ''learning curve analysis ignores a host of pressures that will be pushing average battery prices higher between now and 2032,'' which include ''batteries that can power longer-range EVs'' and ''battery suppliers that can access lithium and other key raw materials at an affordable price.''

NHTSA disagrees with commenters that battery costs will continue to plateau indefinitely or increase in the rulemaking timeframe and believes that battery costs will continue to trend downward in the mid- and long-term. BNEF has since continued to predict a reduction in lithium-ion battery pack price since the BNEF article referenced in POET's comments, stating ''[l]ithium prices reached a high point at the end of 2022, but fears that prices would remain high have largely subsided since then and prices are now falling again.'' [541] This is in agreement with expert interagency projections from our working group with DOE/Argonne and EPA,[542] in addition to other recent trends [543] and expert projections [544] [545] However, NHTSA does agree that mineral prices have remained elevated during the time of this rulemaking, which is reflected in us continuing to incorporate a learning plateau from MY 2022 to MY 2025 as we did in the NPRM—holding our battery learning rate constant to account for potential fluctuating mineral prices.[546]

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[530] ZETA, Docket No. NHTSA–2023–0022–60508–A1, at 16–17.

[531] DOE. Office of Energy Efficiency & Renewable Energy. 2023. FOTW #1272, January 9, 2023: Electric Vehicle Battery Pack Costs in 2022 Are Nearly 90% Lower than in 2008, according to DOE Estimates. Available at: *https://www.energy.gov/eere/vehicles/articles/fotw-1272-january-9-2023-electric-vehicle-battery-pack-costs-2022-are-nearly*. (Accessed: Apr. 5, 2024).

[532] ICCT, Docket No. NHTSA–2023–0022–54064–A1, at 12.

[533] Slowik, P. et al. 2022. Assessment of Light-Duty Electric Vehicle Costs and Consumer Benefits in the United States in the 2022–2035 Time Frame. International Council on Clean Transportation. Available at: *https://theicct.org/wp-content/uploads/2022/10/ev-cost-benefits-2035-oct22.pdf*. (Accessed: Feb. 12, 2024).

[534] POET, Docket No. NHTSA–2023–0022–61561–A1, at 17–18.

[535] POET cites the older BNEF article from July 2022 instead of December 2022: BNEF. 2022. The Race to Net Zero: The Pressures of the Battery Boom in Five Charts. Last revised: July 21, 2022. Available at: *https://about.bnef.com/blog/race-to-net-zero-the-pressures-of-the-battery-boom-in-five-charts/*. (Accessed: Mar. 12, 2024).

[536] POET, Docket No. NHTSA–2023–0022–61561–A1, at 17–18.

[537] CFDC et al., Docket No. NHTSA–2023–0022–62242–A1, at 13; Valero, Docket No. NHTSA–2023–0022–58547–A4, at 4; AFPM, Docket No. NHTSA–2023–0022–61911–A2, at 47.

[538] Thornhill, J. 2022. Morgan Stanley Flags EV Demand destruction as Lithium Soars. Bloomberg. Chart 7. Available at: *https://www.bloomberg.com/news/articles/2022-03-25/morgan-stanley-flags-ev-demand-destruction-as-lithium-soars*. (Accessed: Apr. 5, 2024).

[539] Valero, Docket No. NHTSA–2023–0022–58547–A4, at 4.

[540] CFDC et al., Docket No. NHTSA–2023–0022–62242–A1, at 13.

[541] BloombergNEF. November 23, 2023. Lithium-Ion Battery Pack Prices Hit Record Low of $139/kWh. Available at: *https://about.bnef.com/blog/lithium-ion-battery-pack-prices-hit-record-low-of-139-kwh/*. (Accessed: Mar. 12, 2024).

[542] ANL. 2024. Cost Analysis and Projections for U.S.-Manufactured Automotive Lithium-ion Batteries. ANL/CSE–24/1. Available at: *https://publications.anl.gov/anlpubs/2024/01/187177.pdf*. (Accessed: Mar. 12, 2024).

[543] Benchmark Mineral Intelligence. Cathode & Anode monthly subscriptions. Available at: *https://benchmarkminerals.com/*. (Accessed: Mar. 12, 2024).

[544] Benchmark Mineral Intelligence. ''Lithium ion cell prices fall below $100 per kWh: Battery market—2023 in Review.'' Dec. 21 2023. Available at: *https://source.benchmarkminerals.com/video/watch/lithium-ion-cell-prices-fall-below-100-per-kwh-battery-market-2023-in-review*. (Accessed: Apr. 10, 2024.)

[545] Liu, S. and Patton, D. 2023. China Lithium Price Poised for Further Decline in 2024.—Analysts. Reuters, December 19, 2023. Available at: *https://www.reuters.com/markets/commodities/china-lithium-price-poised-further-decline-2024-analysts-2023-12-01/*. (Accessed: Apr. 5, 2024).

[546] Trading Economics. Commodity: Lithium. Available at: *https://tradingeconomics.com/*

We have also considered many of these challenges identified by Valero to the extent possible for this final rule. In addition to continuing the learning curve plateau from MY 2022 to MY 2025 to account for materials-related uncertainties, mentioned above, we worked with DOE/Argonne and EPA to conduct an analysis that confirms the availability of raw materials for batteries, such as lithium.[547] While the analysis from DOE is exogenous to our CAFE Model analysis for the final rule, it does confirm that the availability of battery materials necessary to support the BEVs projected to be built in NHTSA's reference baseline projection as a function of ZEV programs or expected manufacturer production at levels consistent with ACC II levels.

We received additional comment from Valero stating, ''NHTSA should not embed chemistry changes into the 'learning effect.' NHTSA should instead forecast between now and 2032 what fraction of new vehicles will have one battery design versus another and develop cost estimates for each battery design,'' [548] citing that the only major change in chemistry is likely towards LFP. We also received related comment from Rivian stating, ''we encourage the agency to elaborate on the extent to which it considered battery cell chemistry trends as they relate specifically to the HDPUV fleet'' [549] and that it was unclear whether the NMC battery chemistry applied to the HDPUV fleet, specifically that the ''logic of applying LFP in this market is so compelling that it could become the chemistry of choice in the very near term.''

We thank Valero and Rivian for providing comment and agree that LFP should be considered in our battery learning curve. Since our NPRM, we have updated our learning curves to accommodate these concerns—including in the HDPUV fleet. NHTSA and EPA worked with DOE/Argonne to distinguish a battery learning curve that is dynamic over the rulemaking period in the following ways: (1) there is a unique learning curve for each powertrain type (HEV or PHEV/BEV) and vehicle type (compact passenger car through the HDPUV space), which is based primarily on battery pack energy and power for the specific vehicle; [550] (2) there is now a weighted mix between cathode chemistries (NMC vs LFP) throughout the rulemaking period to accommodate the increased prevalence of LFP in the market.[551] NHTSA continues to collaborate with other agencies in developing battery-related metrics for rulemakings that are reflective of industry.

Finally, we received comment from POET on our battery cost curves where they cited comments on EPA's recent ''vehicle GHG proposed rule'' where POET commented that they found ''substantial learning related to the production of BEV componentry has already occurred in the light-duty vehicle sector as evidenced by the current mass production of BEVs and further learning curve benefits would therefore be expected to be much smaller than those assumed by U.S. EPA.'' [552] Further, POET stated that NHTSA ''should not rely on battery pack learning curves that have significant uncertainties to increase the stringency of the CAFE regulations.'' POET gave no further guidance on how our battery learning curve could be changed to account for these uncertainties.

While we agree that there have been advancements in the battery production process, those advancements have been captured in our BatPaC-based circa-MY 2022 battery costs as well as our future battery costs. The BatPaC model is used to set our base year battery costs as well as our battery learning curve, which are dependent on vehicle/powertrain metrics as well as battery-related parameters (such as chemistry, production volume, production efficiency, labor rates, equipment costs and material costs, to name a few). Additionally, we examined several battery cost sensitivity cases, which explore variations of battery cost DMCs as well as material costs; more information on these sensitivities can be found in RIA Chapter 9.2.2 and the Final Rule Battery Costs Docket Memo. We believe our BatPaC-based circa-MY 2022 battery costs and future costs via the learning curve have been developed in a transparent way that involved feedback from stakeholders and expertise from leading government experts on battery-related issues. Despite high-granularity with modeling, there are still inherent uncertainties with modeling any metric (such as fuel prices, for instance); however, just because something is uncertain doesn't mean we shouldn't model it—this is why we sought comment from stakeholders on our inputs and assumptions and have incorporated that feedback in the final rule analysis as discussed in more detail.

For this analysis, to reflect the evolution of battery manufacturing, comments from stakeholders, and for better alignment of battery assumptions between government agencies, the Department of Energy and Argonne, with significant input from NHTSA and EPA, developed battery cost correlation equations from BatPaC for use in both the NHTSA CAFE and EPA GHG analyses.[553] These cost equations—developed for use through MY 2035—were tailored for different vehicle segments,[554] different levels of electrification,[555] and anticipated plant production volumes.[556] These equations represent cost improvements achieved from advanced manufacturing, pack design, and cell design with current and anticipated future battery chemistries,[557] design parameters,

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commodity/lithium. (Accessed: Apr. 10, 2024); Barlock, T.A. et al. 2024. Securing Critical Materials for the U.S. Electric Vehicle Industry. ANL–24/06. Final Report. Available at: *https://publications.anl.gov/anlpubs/2024/03/187907.pdf*. (Accessed: Apr. 5, 2024). Benchmark Mineral Intelligence. 2023. Lithium price decline casts shadow over long-term supply prospects—2023 in review. Dec. 22, 2023. Available at: *https://source.benchmarkminerals.com/article/lithium-price-decline-casts-shadow-over-long-term-supply-prospects-2023-in-review*. (Accessed: Apr. 10, 2024.)

[547] Barlock, T.A. et al. February 2024. Securing Critical Materials for the U.S. Electric Vehicle Industry. ANL–24/06. Final Report. Available at: *https://publications.anl.gov/anlpubs/2024/03/187907.pdf*. (Accessed: Apr. 5, 2024).

[548] Valero, Docket No. NHTSA–2023–0022–58547–A4, at 5–6.

[549] Rivian, Docket No. NHTSA–2023–0022–59765–A1, at 16.

[550] Autonomie full vehicle model simulation data was used to determine average battery pack energy across vehicle segments. For details of how Autonomie Full Vehicle Model simulations was used for this rulemaking see TSD Chapter 2.4.

[551] Referred to as a ''composite correlation equation'' earlier in this section.

[552] POET, Docket No. NHTSA–2023–0022–61561–A1, at 18.

[553] ANL. 2024. Cost Analysis and Projections for U.S.-Manufactured Automotive Lithium-ion Batteries. ANL/CSE–24/1. Available at: *https://publications.anl.gov/anlpubs/2024/01/187177.pdf*. (Accessed: Mar. 12, 2024); EPA. Final Rule: Multi-Pollutant Emissions Standards for Model Years 2027 and Later Light-Duty and Medium-Duty Vehicles. 2024. Available at: *https://www.epa.gov/regulations-emissions-vehicles-and-engines/regulations-greenhouse-gas-emissions-passenger-cars-and*. See EPA's RIA section 2.5.2.1 Battery cost modeling methodology.

[554] The vehicle classes considered in this project include compact cars, midsize cars, midsize SUVs, and pickup trucks.

[555] The levels of electrification considered in this project include light-duty HEVs, PHEVs, and BEVs (~250 and ~300 mile ranges) as well as medium/heavy-duty BEVs.

[556] Production volumes were determined for each vehicle class and type for each model year. See, U.S. Department of Energy. Argonne National Laboratory. Cost Analysis and Projections for U.S.-Manufactured Automotive Lithium-ion Batteries. ANL/CSE–24/1. Equation 1 and Table 13. Available at: *https://www.osti.gov/biblio/2280913/*. (Accessed: Jan. 25, 2024).

[557] Battery cathode chemistries considered in this project include nickel-based materials (NMC622, NMC811, NMC95, and LMNO) as well as lower-cost LFP cathodes; varying percentages of silicon

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forecasted market prices, and vehicle technology penetration. Please see Argonne's Cost Analysis and Projections for U.S.-Manufactured Automotive Lithium-ion Batteries report for a more detailed discussion of the inputs and assumptions that were used to generate these cost equations.[558] The methodology outlined in the report is largely the same that we used in previous rules, which utilized the most up-to-date BatPaC model to estimate future battery costs based on current chemistries, production volumes, and projected material prices.

Similar to our past BatPaC-based estimates for a battery learning curve, the employed learning curve explicitly assumes particular battery chemistry is used; unlike in previous rulemakings, however, a dynamic NMC/LFP mix has been incorporated into the learning curve in collaboration with EPA and DOE/Argonne, which is discussed in more detail below. We believe that during the rulemaking time frame, based on ongoing research and discussions with stakeholders,[559] the industry will continue to employ lithium-ion NMC as the predominant battery cell chemistry for the near-term but will transition more fully to advanced high-nickel battery chemistries [560] like NMC811 or less-costly cell chemistries like LFP–G during the middle or end of the decade—*i.e.,* during the rulemaking timeframe. We acknowledge there are other battery cell chemistries currently being researched that reduce the use of cobalt, use solid opposed to liquid electrolyte, use of silicon-dominant anodes or lithium-metal anodes, or even eliminate use of lithium in the cell altogether; [561] however, at this time, we are limiting battery chemistry to NMC622, NMC811, and LFP for this rulemaking but will continue to monitor work from DOE and related government agencies as well as other developments in the advancement of battery cell chemistries.[562]

As discussed above, due to the potential increasing prevalence of LFP displacing NMC cathodes in the U.S. EV market,[563] especially in the rulemaking years, NHTSA uses a dynamic NMC/LFP mix between the battery cost correlation equations, referred to as a composite correlation equation; LFP market projections [564] used for the mix are noted in TSD Chapter 3.3. LFP market share starts at 1 percent in MY 2021 and grows to 19 percent in MY 2028. For the model years that the composite cost equation covers (for MYs through 2035), NMC battery cathode chemistry is assumed for the remaining market share. Note the composite cost equation only corresponds with BEV and PHEV electrification technologies and not HEV or FCEV electrification technologies. For more information on the development of battery learning curves, please see TSD Chapter 3.3.5.3.1.

Beyond the extent of the battery cost correlation equation, starting in MY 2036, a constant 1.5% learning rate was used through MY 2050.[565] NHTSA used this constant rate due to uncertainty associated with reducing the cost of the pack below the cost of the raw material to build the pack in that far out time frame.

As there are inherent uncertainties in projecting future technology costs such as battery pack due to several factors, including the timing of the analysis used to support this final rule, we performed several battery-related cost sensitivity analyses. These include cases increasing the battery pack DMCs by 25%, decreasing the battery pack DMC by 15%, high and low mineral costs, and a curve we used for the NPRM. These results are presented in Chapter 9 of the FRIA. One important point that these sensitivity case results emphasize is that because of NHTSA's inability to consider manufacturers building BEVs and consider the combined fuel economy of PHEVs in response to CAFE standards during standard-setting years (*i.e.,* MYs 2027–2031 for this final rule), net social costs and benefits do not change significantly between battery cost sensitivity cases, and similarly would not change significantly if much lower battery costs were used.

Additional discussion in TSD Chapter 3 shows that our projected costs fall fairly well in the middle of the range of other costs projected by various studies and organizations for future years.[566] Using the same approach as the rest of our analysis—that our costs should represent an average achievable performance across the industry—we believe that the battery DMCs with the learning curve applied provide a reasonable representation of potential future costs across the industry, based on the information available to us at the time of the analysis for this final rule was completed. RIA chapter 9.2.2 shows how our reference and sensitivity case cost projections change over time using different base year and learning assumptions.

We received two other comments suggesting the price of BEVs are not accurately accounted for in our analysis. CEA and the Corn Growers Associations stated that NHTSA bases its technology costs on nominal prices or MSRP, which do not reflect actual costs to manufacturers.[567] [568] Both commenters stated that this does not reflect reality, as vehicle manufacturers have been reportedly cross-subsidizing electric vehicle costs to different extents since introducing their electrified vehicles.

NHTSA disagrees with these comments and believes that a fundamental misunderstanding of how technology costs are calculated in the analysis could have led to this mistake

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content (5%, 15%, and 35%) within a graphite anode were considered, as well.

[558] ANL. 2024. Cost Analysis and Projections for U.S.-Manufactured Automotive Lithium-ion Batteries. ANL/CSE–24/1. Available at: *https://publications.anl.gov/anlpubs/2024/01/187177.pdf.* (Accessed: Mar. 12, 2024).

[559] Docket Submission of Ex Parte Meetings Prior to Publication of the Corporate Average Fuel Economy Standards for Passenger Cars and Light Trucks for Model Years 2027–2032 and Fuel Efficiency Standards for Heavy-Duty Pickup Trucks and Vans for Model Years 2030–2035 Notice of Proposed Rulemaking memorandum, which can be found under References and Supporting Material in the rulemaking Docket No. NHTSA–2023–0022.

[560] Panayi, A. 2023. Into the Next Phase, the EV Market Towards 2030—The TWh year: The Outlook for the EV & Battery Markets in 2023. RhoMotion. Available at: *https://rhomotion.com/rho-motion-seminar-series-live-q1-2023-seminar-recordings.* (Accessed: May 31, 2023).

[561] Slowik, P. et al. 2022. Assessment of Light-Duty Electric Vehicle Costs and Consumer Benefits in the United States in the 2022–2035 Time Frame. International Council on Clean Transportation. Available at: *https://theicct.org/wp-content/uploads/2022/10/ev-cost-benefits-2035-oct22.pdf.* (Accessed: May 31, 2023); Batteries News. 2022. Solid-State NASA Battery Beats The Model Y 4680 Pack at Energy Density by Stacking all Cells in One Case. Last revised: October 20, 2022. Available at: *https://batteriesnews.com/solid-state-nasa-battery-beats-model-y-4680-pack-energy-density-stacking-cells-one-case/.* (Accessed: May 31, 2023).

[562] Barlock, T.A. et al. February 2024. Securing Critical Materials for the U.S. Electric Vehicle Industry. ANL–24/06. Final Report. Available at: *https://publications.anl.gov/anlpubs/2024/03/187907.pdf.* (Accessed: Apr. 5, 2024).

[563] Gohlke, D. et al. March 2024. Quantification of Commercially Planned Battery Component Supply in North America through 2035. Final Report. ANL–24/14. Available at: *https://publications.anl.gov/anlpubs/2024/03/187735.pdf.* (Accessed: Apr. 5, 2024).

[564] A composite learning curve (used for PHEV and BEV battery cost projections) was developed, in coordination with DOE/ANL and EPA, to include a North American market mix of NMC and LFP chemistries (dynamic, over time); the NMC/LFP market presence projections values were based on (averaged, rounded, and smoothed) Rho Motion and Benchmark Mineral Intelligence proprietary data.

[565] Like in our other parts of this analyses, there are uncertainties associated with predicting estimated costs beyond 2035. Additionally, like our estimated learning curves for other technologies beyond this time frame, we used a similar convervative estimate continue learning down technology costs without having to fall below the costs of raw material to make the components.

[566] TSD Chapter 3.3, Figure 3–32: Comparing Battery Pack Cost Estimates from Multiple Sources.

[567] CFDC et al, Docket No. NHTSA–2023–0022–62242–A1, at 11.

[568] CEA, Docket No. NHTSA–2023–0022–61918–A1, at 24.

in the commenters' comprehension of this issue. While all of these concepts were described in detail in the NPRM and Draft TSD (and now this final rule and Final TSD), we will summarize the relevant concepts here. Please see Final TSD Chapter 2.4., Technology Costs, for more detailed information. Our technology costs are from real price teardowns and ground up assembly costs of the component being added to the vehicle.[569] When vehicles adopt technologies in the reference baseline or in response to standards in the analysis, the costs for those technologies are based on the incremental addition of the ground up costs to the reference price, which in this case is the vehicle price. Note that we determine the direct manufacturing costs of the components first, then apply a retail price equivalent markup to that cost before incrementally applying the technology cost to the vehicle price.[570] TSD Chapter 3.3 discusses in detail in how we have developed the ground up costs for BEV batteries and components, and TSD Chapter 2.4 discusses how we account for direct manufacturing costs and retail costs.

We also received several comments related to electric vehicle maintenance[571] and battery replacement costs.[572] For more information on repair/maintenance costs, please see Preamble Section III.G.3.

While batteries and relative battery components are the biggest cost driver of electrification, non-battery electrification components, such as electric motors, power electronics, and wiring harnesses, also add to the total cost required to electrify a vehicle. Different electrified vehicles have variants of non-battery electrification components and configurations to accommodate different vehicle classes and applications with respective designs; for instance, some BEVs may be engineered with only one electric motor and some BEVs may be engineered with two or even four electric motors within their powertrain to provide all wheel drive function. In addition, some electrified vehicle types still include conventional powertrain components, like an ICE and transmission.

For all electrified vehicle powertrain types, we group non-battery electrification components into four major categories: electric motors (or e-motors), power electronics (generally including the DC–DC converter, inverter, and power distribution module), charging components (charger, charging cable, and high-voltage cables), and thermal management system(s). We further group the components into those comprising the electric traction drive system (ETDS), and all other components. Although each manufacturer's ETDS and power electronics vary between the same electrified vehicle types and between different electrified vehicle types, we consider the ETDS for this analysis to be comprised of the e-motor and inverter, power electronics, and thermal system.

When researching costs for different non-battery electrification components, we found that different reports vary in components considered and cost breakdown. This is not surprising, as vehicle manufacturers use different non-battery electrification components in different vehicles systems, or even in the same vehicle type, depending on the application. In order of the component categories discussed above, we examined the following cost teardown studies discussed in TSD 3.3.5 on Table 3–82. Using the best available estimate for each component from the different reports captures components in most manufacturer's systems but not all; we believe, however, that this is a reasonable metric and approach for this analysis, given the non-standardization of electrified powertrain designs and subsequent component specifications. Other sources we used for non-battery electrification component costs include an EPA-sponsored FEV teardown of a 2013 Chevrolet Malibu ECO with eAssist for some BISG component costs,[573] which we validated against a 2019 Dodge Ram eTorque system's publicly available retail price,[574] and the 2015 NAS report.[575] Broadly, our total BISG system cost, including the battery, fairly matches these other cost estimates.

While the majority of electric vehicle cost comments related to batteries, we did receive three comments pertaining to non-battery electrification costs or electrification costs more generally. The Strong PHEV Coalition asserted that despite agreeing with other costs in the analysis,[576] our PHEV50 transmission costs (as shown in the Draft TSD Table 3–89) "disagrees with ANL's previous studies which show a transmission for about $1600 less than shown in the draft technical support document,"[577] referencing an Argonne Light Duty Vehicle Techno-Economic Analysis[578] and quoted, "ANL shows a PHEV transmission cost of $793." Additionally, the Strong PHEV Coalition stated, "several additional technical modifications can lower the cost of PHEVs that most analyses do not consider," without providing further specifics.

Upon inspection of the cited Argonne reference, the stated $793 value (or any PHEV50 transmission specific value) could not be found in documentation (in neither the Part One light-duty section nor the Part Two medium-heavy duty section); the only information on PHEV transmissions in the document relates to the number of transmission gears, and the only component-specific costs live in the medium-heavy duty section (without a specific transmission cost given).[579] We use the cost of the AT8L2 transmission as a cost proxy for the hybrid transmission architecture in P2 hybrid systems and CVTL2 transmission architecture in SHEVPS hybrid systems, whose DMCs are based on estimates from Table 8A.2a of the 2015 NAS report; these transmissions are used for other powertrain configurations in the analysis and represents costs that have been agreed on by industry today.[580]

John German argued that our power-split hybrid costs are "incomprehensively high compared with both NHTSA's own previous estimates and with independent cost assessments."[581] John German claimed that the teardown study conducted by FEV North America, Inc.[582] "on 2013

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[569] *See, e.g.,* Final TSD, Chapter 2.4.1 ("The analysis uses agency-sponsored tear-down studies of vehicles and parts to estimate the DMCs of individual technologies, in addition to independent tear-down studies, other publications, and CBI.").

[570] *See, e.g.,* Final TSD, Chapter 2.4.2, Table 2–24: Retail Price Components, and the discussion of our methodology to estimate indirect costs.

[571] Consumer Reports, Docket No. NHTSA–2023–0022–61101–A2, at 11–12.

[572] Heritage Foundation, Docket No. NHTSA–2023–0022–61952–A1, at 12–13; ACI, Docket No. NHTSA–2023–0022–50765–A1, at 2–4; AFPM, Docket No. NHTSA–2023–0022–61911–A2, at 51.

[573] FEV. 2014. Light Duty Vehicle Technology Cost Analysis 2013 Chevrolet Malibu ECO with eAssist BAS Technology Study. FEV P311264. Contract no. EP–C–12–014, WA 1–9.

[574] Colwell, K.C. 2019. The 2019 Ram 1500 eTorque Brings Some Hybrid Tech, If Little Performance Gain, to Pickups. Last revised: Mar. 14, 2019. Available at: *https://www.caranddriver.com/reviews/a22815325/2019-ram-1500-etorque-hybrid-pickup-drive.* (Accessed: May 31, 2023).

[575] 2015 NAS report, at 305.

[576] Strong PHEV Coalition, Docket No. NHTSA–2023–0022–60193–A1, at 3.

[577] Strong PHEV Coalition, Docket No. NHTSA–2023–0022–60193–A1, at 7.

[578] ANL—ESD–2110 Report—BEAN Tool—Light Duty Vehicle Techno-Economic Analysis. Available at: *https://publications.anl.gov/anlpubs/2021/10/171713.pdf.* (Accessed: Apr. 5, 2024).

[579] NHTSA coordinated with Argonne about this reference and Argonne confirmed that the $793 value is not directly provided in their report.

[580] 2015 NAS report, at 298–99.

[581] John German, Docket No. NHTSA–2023–0022–53274–A1, at 2.

[582] The 2013 FEV study for ICCT is titled "Light-Duty Vehicle Technology Cost Analysis European

Continued

hybrids found mid-size car powersplit hybrid direct manufacturing cost (DMC) is about $2,050—far below the estimated DMC of $2,946 for electrical components alone in Table 3–89 of the proposed rule TSD that excludes the battery cost.'' [583]

NHTSA has responded to this comment in prior rules, extensively detailing the agency's reasons for not relying on particular FEV studies to estimate hybrid costs.[584] Upon further examination of the FEV document, the ''Net Incremental Direct Manufacturing Cost'' for a midsize passenger car for power-split HEVs was stated as ''€2,230'' [585] (or approximately $2,943 in 2012$ and about $3,474 in 2021$). Taking a different approach, converting John German's stated value of $2,050 into Euros (which is approximately €1,553, used to search within the FEV study), it is found that this is a value that is listed for a subcompact power-split hybrid in Table E–5 titled ''Power-Split Hybrid Electric Vehicle Case Study Results Eastern Europe Labor Rate Substitution.'' As detailed extensively in the documentation supporting our analysis, we consider ten vehicle classes, and we believe a subcompact vehicle is only likely to represent vehicles covering a small portion of the vehicles we consider.

Further, the commenter oversimplifies a technology walk between powertrains in a given model year, stating a 2023 Toyota Camry ''SE list price is $27,960 and SE hybrid is $30,390, for an increment of $2,430. If RPE is 1.5, then DMC is $1,620.'' As discussed in more detail in Final TSD Chapter 2.4 and referenced in a comment response above, we do not use vehicle prices to estimate technology costs, rather we estimate technology costs from the ground-up. For a more-accurate representation of a technology walk from a conventional powertrain to a power-split powertrain, see RIA Chapter 4.[586] We have not made any changes to power-split hybrid costs for this final rule.

As discussed earlier in Section III.C, our technology costs account for three variables: retail price equivalence (RPE), which is 1.5 times the DMC, the technology learning curve, and the adjustment of the dollar value to 2021$ for this analysis. While HDPUVs have larger non-battery electrification componentry than LDVs, the cost calculation methodology is identical, in that the $/kW metric is the same, but the absolute costs are higher. As a result, HDPUVs and LDVs share the same non-battery electrification DMCs.

For the non-battery electrification component learning curves, in both the LD and HDPUV fleets, we used cost information from Argonne's 2016 Assessment of Vehicle Sizing, Energy Consumption, and Cost through Large-Scale Simulation of Advanced Vehicle Technologies report.[587] The report provides estimated cost projections from the 2010 lab year to the 2045 lab year for individual vehicle components.[588] We considered the component costs used in electrified vehicles and determined the learning curve by evaluating the year over year cost change for those components. Argonne published a 2020 and a 2022 version of the same report; however, those versions did not include a discussion of the high and low-cost estimates for the same components.[589] Our learning estimates generated using the 2016 report align in the middle of these two ranges, and therefore we continue to apply the learning curve estimates based on the 2016 report. There are many sources that we could have picked to develop learning curves for non-battery electrification component costs, however given the uncertainty surrounding extrapolating costs out to MY 2050, we believe these learning curves provide a reasonable estimate.

In summary, we calculate total electrified powertrain costs by summing individual component costs, which ensures that all technologies in an electrified powertrain appropriately contribute to the total system cost. We combine the costs associated with the ICE (if applicable) and transmission, non-battery electrification components like the electric machine, and battery pack to create a full-system cost. Chapter 3.3.5.4 of the TSD presents the total costs for each electrified powertrain option, broken out by the components we discussed throughout this section. In addition, the chapter discusses where to find each of the component costs in the CAFE Model's various input files.

4. Road Load Reduction Paths

No car or truck uses energy (whether gas or otherwise) 100% efficiently when it is driven down the road. If the energy in a gallon of gas is thought of as a pie, the amount of energy ultimately available from that gallon to propel a car or truck down the road would only be a small slice. So where does the lost energy go? Most of it is lost due to thermal and frictional loses in the engine and drivetrain and drag from ancillary systems (like the air conditioner, alternator generator, various pumps, etc.). The rest is lost to what engineers call road loads. For the most part, road loads include wind resistance (or aerodynamics), drag in the braking system, and rolling resistance from the tires. At low speeds, aerodynamic losses are very small, but as speeds increases these loses rapidly become dramatically higher than any other road load. Drag from the brakes in most cars is practically negligible. ROLL losses can be significant: at low speeds ROLL losses can be more than aerodynamic losses. Whatever energy is left after these road loads are spent on accelerating the vehicle anytime a its speed increases. This is where reducing the mass of a vehicle is important to efficiency because the amount of energy to accelerate the vehicle is always directly proportional to a vehicle's mass. All else being equal, reduce a car's mass and better fuel economy is guaranteed. However, keep in mind that at freeway speeds, aerodynamics plays a more dominant role in determining fuel economy than any other road load or than vehicle mass.

We include three road load reducing technology paths in this analysis: the MR Path, Aerodynamic Improvements (AERO) Path, and ROLL Path. For all three vehicle technologies, we assign analysis fleet technologies and identify adoption features based on the vehicle's body style. The LD fleet body styles we include in the analysis are convertible,

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Vehicle Market Updated Indirect Cost Multiplier (ICM) Methodology'' and can be downloaded from ICCT's website.

[583] Mid-size car emphasized. Note that our DMC is in 2021$.

[584] 85 FR 24431–2, 85 FR 42513–4 (April 30, 2020), 87 FR 25801–2 (May 2, 2022).

[585] John German's Table A.3 shows that this cost includes not only the electric machines but also the battery, high-voltage cables, etc. Recall that our quoted cost excludes the battery.

[586] Memorandum to Docket No. NHTSA–2023–0022, Electrification Technology Cost Walk in Support of the Corporate Average Fuel Economy Standards for Passenger Cars and Light Trucks for Model Years 2027 and Beyond and Fuel Efficiency Standards for Heavy-Duty Pickup Trucks and Vans for Model Years 2030 and Beyond.

[587] Moawad, A. et al. 2016. Assessment of Vehicle Sizing, Energy Consumption and Cost Through Large Scale Simulation of Advanced Vehicle Technologies. ANL/ESD–15/28. Available at: *https://www.osti.gov/biblio/1245199.* (Accessed: May 31, 2023).

[588] DOE's lab year equates to five years after a model year, *e.g.,* DOE's 2010 lab year equates to MY 2015. ANL/ESD–15/28 at 116.

[589] Islam, E. et al. 2020. Energy Consumption and Cost Reduction of Future Light-Duty Vehicles through Advanced Vehicle Technologies: A Modeling Simulation Study Through 2050. ANL/ESD–19/10. Available at: *https://publications.anl.gov/anlpubs/2020/08/161542.pdf.* (Accessed: May 31, 2023); Islam, E. et al. 2022. A Comprehensive Simulation Study to Evaluate Future Vehicle Energy and Cost Reduction Potential. ANL/ESD–22/6. Available at: *https://publications.anl.gov/anlpubs/2023/11/179337.pdf.* (Accessed: Mar. 14, 2024).

coupe, sedan, hatchback, wagon, SUV, pickup, minivan, and van. The HDPUV fleet body styles include chassis cab, cutaway, fleet SUV, work truck, and work van. Figure III–7 and Figure III–8 show the LD and HDPUV fleet body styles used in the analysis.

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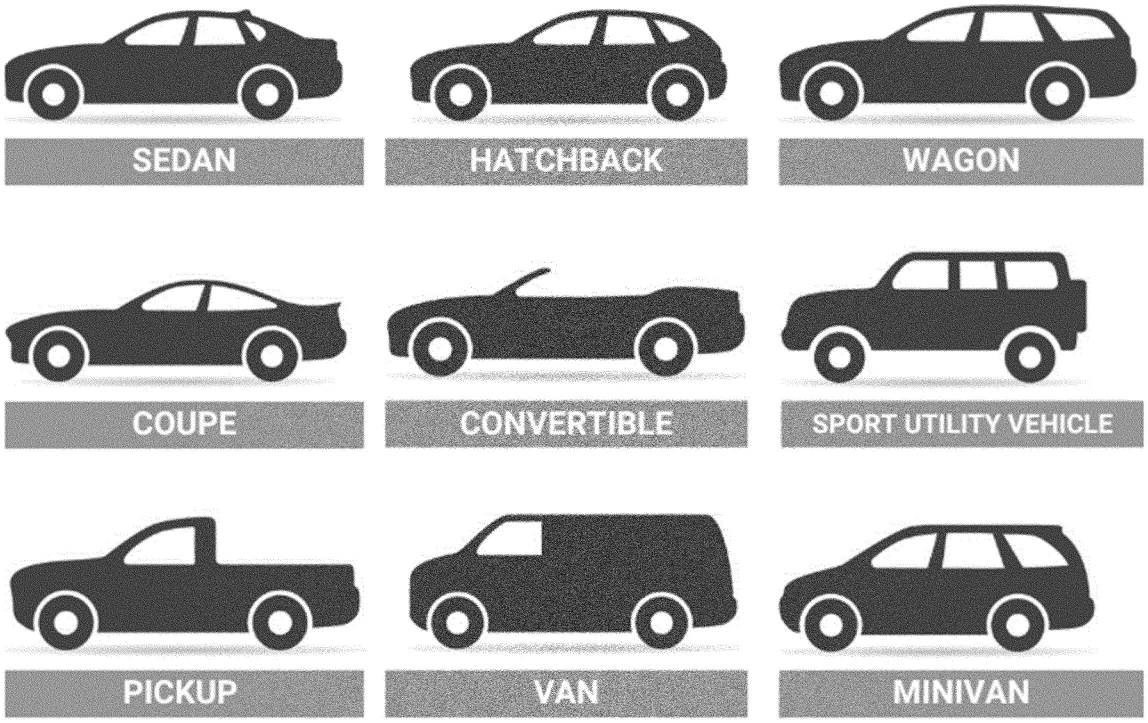

Figure III-7: LD Fleet Body Styles

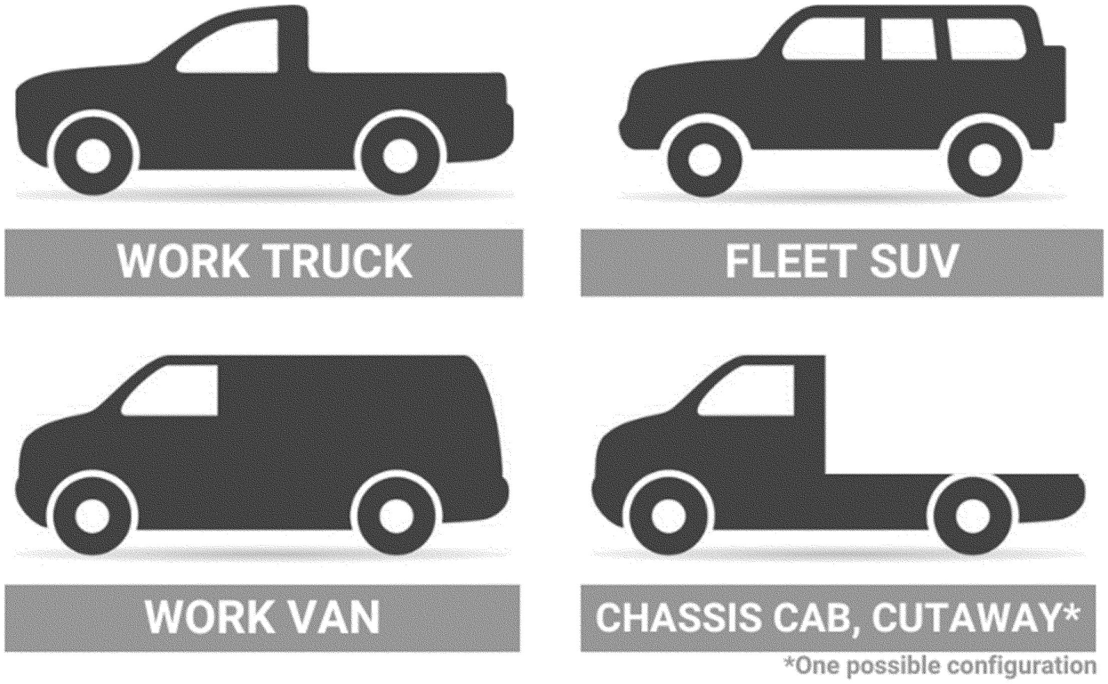

Figure III-8: HDPUV Fleet Body Styles

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As expected, the road load forces described above operate differently based on a vehicle's body style, and the technology adoption features and effectiveness values reflect this. The following sections discuss the three Road Load Reduction Paths.

a. Mass Reduction

MR is a relatively cost-effective means of improving fuel economy, and vehicle manufacturers are expected to apply various MR technologies to meet fuel economy standards. Vehicle manufacturers can reduce vehicle mass through several different techniques, such as modifying and optimizing vehicle component and system designs, part consolidation, and adopting materials that are conducive to MR (advanced high strength steel (AHSS), aluminum, magnesium, and plastics including carbon fiber reinforced plastics).

We received multiple comments on how this analysis evaluated mass reduction as a possible pathway for manufacturers to use to meet the standards. Raw aluminum supplier Arconic, the Aluminum Association, the American Chemistry Council and the California Attorney General commented generally about the benefits of mass reduction to increasing fuel economy.[590] Stakeholders also commented broadly about mass reduction technology given the current state of the vehicle fleet and anticipated future fleet technology transitions. Even given the effectiveness of mass reduction as a pathway to CAFE compliance as well as tightening CAFE standards, multiple aluminum industry members noted that the average mass of vehicles continues to increase. They also noted that there are limited indications of adoption of aluminum primary structure in the fleet and that this will not change by 2032. They also pointed out that significant average mass increases are at least partially being driven by the higher masses associated with BEVs and their heavy batteries. Furthermore, they called on BEV manufacturers to use more aluminum to offset the higher masses associated with the batteries in these vehicles. Similarly, the States and Cities commented with research showing that potential fuel economy improvements from mass reduction have not been fully realized because manufacturers add weight back to the vehicle for other reasons, and because of increasing vehicle footprints.[591] Additional discussion of how NHTSA considers various materials in the mass reduction analysis are given below and in TSD Chapter 3.4, and NHTSA's discussion of vehicle footprint trends is located in TSD Chapter 1.

For the LD fleet portion of this analysis, we considered five levels of MR technology (MR1–MR5) that include increasing amounts of advanced materials and MR techniques applied to the vehicle's glider.[592] The subsystems that may make up a vehicle glider include the vehicle body, chassis, interior, steering, electrical accessory, brake, and wheels systems. We accounted for mass changes associated with powertrain changes separately.[593] We considered two levels of MR (MR1–MR2) and an initial level (MR0) for the HDPUV fleet. We use fewer levels because vehicles within the HD fleets are built for a very different duty cycle[594] than those in the LD fleet and tend to be larger and heavier. Moreover, there are different vehicle parameters, like towing capacity, that drive vehicle mass in the HD fleet rather than, for example, NVH (noise, vibration, and harshness) performance in the LD fleet. Similarly, HDPUV MR is assumed to come from the glider,[595] and powertrain MR occurs during the Autonomie modeling. Our estimates of how manufacturers could reach each level of MR technology in the LD and HDPUV analyses, including a discussion of advanced materials and MR techniques, can be found in Chapter 3.4 of the TSD.

A coalition of NGOs stated that achieving the highest degree of mass reduction, MR5, can be achieved in the mainstream fleet with aluminum alone and carbon fiber technology is not necessary.[596] We disagree with this conclusion. While aluminum technology can be a potent mass reduction pathway, it does have its limitations. First, aluminum, does not have a fatigue endurance limit. That is, with aluminum components there is always some combination of stress and cycles when failure occurs. Automotive design engineering teams will dimension highly stressed cross sections to provide an acceptable number of cycles to failure. But this often comes at mass savings levels that fall short of what would be expected purely based on density specific strength and stiffness properties for aluminum.

Looking at real data, the mostly aluminum (cab and bed are made from aluminum), 2021 Ford F150 achieves less than a 14 percent mass reduction compared to its 2014 all-steel predecessor.[597] This is an especially pertinent comparison because both vehicles have the same footprint within a 2% margin and presumably were engineered to similar duty cycles given that they both came from the same manufacturer. Per our regression analysis, the Ford F–150 achieves MR3. As mentioned in the TSD Chapter 3.4, a body in white structure made almost entirely from aluminum is roughly required to get to MR4. It may be possible to achieve MR5 without the use of carbon fiber, but the resultant vehicle would not achieve performance parity with customer expectations in terms of crash safety, noise and vibration levels, and interior content. The discontinued Lotus Elise is an example of an aluminum and fiberglass car that achieved MR5 but represents an

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[590] States and Cities, Docket No. NHTSA–2023–0022–61904; ACC, Docket No. NHTSA–2023–0022–60215; Arconic, Docket No. NHTSA–2023–0022–48374; Aluminum Association, Docket No. NHTSA–2023–0022–58486.

[591] States and Cities, Docket No. NHTSA–2023–0022–61904.

[592] Note that in the previous analysis associated with the MYs 2024–2026 final rule, there was a sixth level of mass reduction available as a pathway to compliance. For this analysis, this pathway was removed because it relied on extensive use of carbon fiber composite technology to an extent that is only found in purpose-built racing cars and a few hundred road legal sports cars costing hundreds of thousands of dollars. TSD Chapter 3.4 provides additional discussion on the decision to include five mass reduction levels in this analysis.

[593] Glider mass reduction can sometimes enable a smaller engine while maintaining performance neutrality. Smaller engines typically weigh less than bigger ones. We captured any changes in the resultant fuel savings associated with powertrain mass reduction and downsizing via the Autonomie simulation. Autonomie calculates a hypothetical vehicle's theoretical fuel mileage using a mass reduction to the vehicle curb weight equal to the sum of mass savings to the glider plus the mass savings associated with the downsized powertrain.

[594] HD vans that are used for package delivery purposes are frequently loaded to GVWR. However, LD passenger cars are never loaded to GVWR. Operators of HD vans have an economic motivation to load their vehicles to GVWR. In contrast studies show that between 38% and 82% of passenger cars are used soley to transport their drivers. (Bureau of Transportation Studies, 2011, FHWA Publication No. FHWA–PL–18–020, 2019).

[595] We also assumed that an HDPUV glider comprises 71 percent of a vehicle's curb weight, based on a review of mass reduction technologies in the 2010 Transportation Research Board and National Research Council's ''Technologies and Approaches to Reducing the Fuel Consumption of Medium- and Heavy-Duty Vehicles.'' See Transportation Research Board and National Research Council. 2010. Technologies and Approaches to Reducing the Fuel Consumption of Medium- and Heavy-Duty Vehicles. Washington, DC: *The National Academies Press.* At page 120–121. Available at: *https://nap.nationalacademies.org/12845/.* (Accessed: May 31, 2023).

[596] National Resource Defense Council et al., Docket No. NHTSA–2023–0022–61944.

[597] Ford. 2021 F–150 Technical Specifications. Available at: *https://media.ford.com/content/dam/fordmedia/North%20America/US/product/2021/f150/pdfs/2021-F-150-Technical-Specs.pdf.* (Accessed on Mar. 21, 2024); Ford. 2014 F–150 Technical Specifications. Available at: *https://media.ford.com/content/dam/fordmedia/North%20America/US/2014_Specs/2014_F150_Specs.pdf.* (Accessed on Mar. 21, 2024).

extremely niche vehicle application that is unlikely to translate to mainstream, high-volume models. Therefore, it is entirely reasonable to assume that carbon fiber ''hang on'' panels and closures would be necessary to achieve MR5 at performance parity.

There were also comments from the NGO coalition regarding the mass reduction section in the NAS study. The commenters noted that the NAS study relies on very little application of carbon fiber technology to achieve their highest level of mass reduction technology. NHTSA would like to note that the NAS study espouses a maximum level of mass reduction of approximately 14.5% using composites (*e.g.,* fiberglass) and carbon fiber technology only in closures structures (*e.g.,* doors, hoods, and decklids) and hang-on panels (*e.g.,* fenders). This is the ''alternative scenario 2'' in the NAS study. This is similar lightweighting technology application strategy to what our analysis roughly associates with MR5, but MR5 requires a 20% mass reduction. In this scenario, we are allotting more mass reduction potential for the same carbon fiber technology application than the NAS study does.

We assigned MR levels to vehicles in both the LD and HDPUV analysis fleets by using regression analyses that consider a vehicle's body design[598] and body style, in addition to several vehicle design parameters, like footprint, power, bed length (for pickup trucks), and battery pack size (if applicable), among other factors. We have been improving on the LD regression analysis since the 2016 Draft Technical Assessment Report (TAR) and continue to find that it reasonably estimates MR technology levels of vehicles in the analysis fleet. We developed a similar regression for the HDPUV fleet for this analysis using the factors described above and other applicable HDPUV attributes and found that it similarly appropriately assigns initial MR technology levels to analysis fleet vehicles. Chapter 3.4 of the TSD contains a full description of the regression analyses used for each fleet and examples of results of the regression analysis for select vehicles.

NHTSA received comments from a coalition of NGOs that the mass reduction regression curves used in the analysis for quantifying analysis fleet mass reduction overestimates the application mass reduction technology in the fleet.[599] They believe that the mass reduction modeling used by Argonne National Lab for estimating powertrain weight in the Autonomie vehicle simulations more accurately reflects how much mass reduction technology is really in the fleet, and stated that we should be using those regression models for the analysis instead. Although we would like to repeat the NGO's calculations to that led them to this opinion, they did not provide enough detail on its methodology and calculations for NHTSA to confirm its accuracy. Consequently, we are only able to respond with general concepts here.

NHTSA disagrees that the methods used by Autonomie to calculate the MR analysis fleet starting levels would lead to a better analysis than our regression. There are multiple reasons for this. First, Autonomie relies on data collected by the subscription benchmarking database A2Mac1 and other limited sources. As much as NHTSA and Argonne rely on data from A2Mac1 for learning about technical aspects of the fleet, it is not representative data for the entire US fleet. Whereas the CAFE mass reduction regressions use data from all vehicles and multiple trim levels in the US fleet (examples discussed above and further in TSD Chapter 3.4), A2Mac1 is limited in the number of vehicles it can teardown in a given year and thus only makes small samples from the US fleet. Using the entire fleet for the regression analysis provides a more accurate snapshot of how vehicles compare to one another when it comes to assigning MR levels to vehicles in the analysis fleets. Second, the NGOs claim that it is better to arrive at a glider weight by taking the average powertrain weight for a given technology class and subtracting that value from the curb weight of all vehicles in the fleet with that same tech class. We calculate a percentage for the powertrain of the curb weight based on the average powertrain mass for all of the technology classes. We then multiply this same percentage (which for the current fleet is 71%) by the curb weight of each vehicle in the fleet to arrive at the glider share. We did not use bespoke powertrain percentages for each corresponding technology class in the fleet because it will most likely not make a substantial difference in how MR is applied. Third, it must also be noted that Autonomie's glider share percent does not take into account sales weighting because Autonomie simulates every possible combination of vehicles and powertrains. By taking into account sales volumes, our analysis does a better job of representing the actual fleet.

The Joint NGOs also commented that the regression model we used for calculating MR for analysis fleet vehicles is invalid because it was developed using prior model year fleets. We disagree. The regression relies on establishing correlations between various vehicle parameters and the mass of a vehicle. For the most part, these correlations reflect physics and automotive design practices that have not changed substantially since these regressions were developed and updated. For example, one parameter correlated in the regression is rear wheel drive (RWD) vs. front wheel drive (FWD). The regression accurately predicts that going from RWD to FWD will save mass. The mass change associated in going from RWD to FWD arises from the elimination of a drive driveshaft and a discrete differential housing (unless the vehicle is mid or rear engine, which is rare in the fleet). This mass change is expected in the same way today as it would have been when the regression was developed. As a second example, another parameter that we correlate in the regression is convertible vs. non-convertible. Convertibles tend to be heavier than, say, sedans because they do not have the upper load path created by having a sedan's roof rail and C- (or D-) pillars. Consequently, manufacturers must compensate by reinforcing the floor pan to account for the lack of a primary load path. This results in higher mass for convertibles. Between when we developed the regression and today, the physics and fundamentals of this structural dynamic have not changed. Hence the regression we use in this regard is still valid today.

There are several ways we ensure that the CAFE Model considers MR technologies like manufacturers might apply them in the real world. Given the degree of commonality among the vehicle models built on a single platform, manufacturers do not have complete freedom to apply unique technologies to each vehicle that shares the same platform. While some technologies (*e.g.,* low rolling resistance tires) are very nearly ''bolt-on'' technologies, others involve substantial changes to the structure and design of the vehicle, and therefore often necessarily affect all vehicle models that share that platform. In most cases, MR technologies are applied to platform level components and therefore the same design and components are used on all vehicle models that share the

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[598] The body design categories we used are 3-box, 2-box, HD pickup, and HD van. A 3-box can be explained as having a box in the middle for the passenger compartment, a box in the front for the engine and a box in the rear for the luggage compartment. A 2-box has a box in front for the engine and then the passenger and luggage box are combined into a single box.

[599] National Resource Defense Council et al., Docket No. NHTSA–2023–0022–61944.

platform. Each vehicle in the analysis fleet is associated with a specific platform family. A platform ''leader'' in the analysis fleet is a vehicle variant of a given platform that has the highest level of MR technology in the analysis fleet. As the model applies technologies, it will ''level up'' all variants on a platform to the highest level of MR technology on the platform. For example, if a platform leader is already at MR3 in MY 2022, and a ''follower'' starts at MR0 in MY 2022, the follower will get MR3 at its next redesign (unless the leader is redesigned again before that time, and further increases the MR level associated with that platform, then the follower would receive the new MR level).

In addition to leader-follower logic for vehicles that share the same platform, we also restrict MR5 technology to platforms that represent 80,000 vehicles or fewer. The CAFE Model will not apply MR5 technology to platforms representing high volume sales, like a Chevrolet Traverse, for example, where hundreds of thousands of units are sold per year. We use this particular adoption feature and the 80,000-unit threshold in particular, to model several relevant considerations. First, we assume that MR5 would require carbon fiber technology.[600] There is high global demand from a variety of industries for a limited supply of carbon fibers; specifically, aerospace, military/defense, and industrial applications demand most of the carbon fiber currently produced. Today, only about 10 percent of the global dry fiber supply goes to the automotive industry, which translates to the global supply base only being able to support approximately 70,000 cars.[601] In addition, the production process for carbon fiber components is significantly different than for traditional vehicle materials. We use this adoption feature as a proxy for stranded capital (*i.e.,* when manufacturers amortize research, development, and tooling expenses over many years) from leaving the traditional processes, and to represent the significant paradigm change to tooling and equipment that would be required to support molding carbon fiber panels. There are no other adoption features for MR in the LD analysis, and no adoption features for MR in the HDPUV analysis.

In the Autonomie simulations, MR technology is simulated as a percentage of mass removed from the specific subsystems that make up the glider. The mass of subsystems that make up the vehicle's glider is different for every technology class, based on glider weight data from the A2Mac1 database[602] and two NHTSA-sponsored studies that examined light-weighting a passenger car and light truck. We account for MR from powertrain improvements separately from glider MR. Autonomie considers several components for powertrain MR, including engine downsizing, and, fuel tank, exhaust systems, and cooling system light-weighting.[603] With regard to the LDV fleet, the 2015 NAS report suggested an engine downsizing opportunity exists when the glider mass is light-weighted by at least 10 percent. The 2015 NAS report also suggested that 10 percent light-weighting of the glider mass alone would boost fuel economy by 3 percent and any engine downsizing following the 10 percent glider MR would provide an additional 3 percent increase in fuel economy.[604] The NHTSA light-weighting studies applied engine downsizing (for some vehicle types but not all) when the glider weight was reduced by 10 percent. Accordingly, the analysis limits engine resizing to several specific incremental technology steps; important for this discussion, engines in the analysis are only resized when MR of 10 percent or greater is applied to the glider mass, or when one powertrain architecture replaces another architecture. For the HDPUV analysis, we do not allow engine downsizing at any MR level. This is because HDPUV designs are sized with the maximum GVWR and GCWR in mind, as discussed earlier in this section. We are objectively controlling the vehicles' utility and performance by this method in Autonomie. For example, if more MR technology is applied to a HD van, the payload capacity increases while maintaining the same maximum GVWR and GCWR.[605] The lower laden weight enables these vehicles to improve fuel efficiency by increased capacity. A summary of how the different MR technology levels improve fuel consumption is shown in TSD Chapter 3.4.4.

Our MR costs are based on two NHTSA light-weighting studies—the teardown of a MY 2011 Honda Accord and a MY 2014 Chevrolet Silverado pickup truck[606]—and the 2021 NAS report.[607] The costs for MR1–MR4 rely on the light-weighting studies, while the cost of MR5 references the carbon fiber costs provided in the 2021 NAS report. The same cost curves are used for the HDPUV analysis; however, we used linear interpolation to shift the HDPUV MR2 curve (by roughly a factor of 20) to account for the fact that MR2 in the HDPUV analysis represents a different level than MR2 in the LD analysis. Unlike the other technologies in our analysis that have a fixed technology cost (for example, it costs about $3,000 to add a AT10L3 transmission to a LD SUV or pickup truck in MY 2027), the cost of MR is calculated on a dollar per pound saved basis based on a vehicle's starting weight. Put another way, for a given vehicle platform, an initial mass is assigned using the aforementioned regression model. The amount of mass to reach each of the five levels of MR is calculated by the CAFE Model based on this number and then multiplied by the dollar per pound saved figure for each of the five MR levels. The dollar per pound saved figure increases at a nearly linear rate going from MR0 to M4. However, this figure increases steeply going from MR4 to MR5 because the technology cost to realize the associated mass savings level is an order of magnitude larger. This dramatic increase is reflected by all three studies we relied on for MR costing, and we believe that it reasonably represents what manufacturers would expect to pay for including increasing amounts of

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[600] See the Final TSD for CAFE Standards for MYs 2024–2026, and Chapter 3.4 of the TSD accompanying this rulemaking for more information about carbon fiber.

[601] Sloan, J. 2020. Carbon Fiber Suppliers Gear up for Next Generation Growth. Last revised: Jan. 1, 2016. Available at: *https://www.compositesworld.com/articles/carbon-fiber-suppliers-gear-up-for-next-gen-growth.* (Accessed: May 31, 2023).

[602] A2Mac1: Automotive Benchmarking. Available at: *https://portal.a2mac1.com/.* (Accessed: May 31, 2023). The A2Mac1 database tool is widely used by industry and academia to determine the bill of materials (a list of the raw materials, sub-assemblies, parts, and quantities needed to manufacture an end-product) and mass of each component in the vehicle system.

[603] Although we do not acount for mass reduction in transmissions, we do reflect design improvements as part of mass reduction when going from, for example, an older AT6 to a newer AT8 that has similar if not lower mass.

[604] NRC. 2015. Cost, Effectiveness, and Deployment of Fuel Economy Technologies for Light-Duty Vehicles. *The National Academies Press:* Washington DC. Available at: *https://doi.org/10.17226/21744.* (Accessed: May 31, 2023).

[605] Transportation Research Board and National Research Council. 2010. Technologies and Approaches to Reducing the Fuel Consumption of Medium- and Heavy-Duty Vehicles. *The National Academies Press:* Washington, DC at 116. Available at: *https://nap.nationalacademies.org/12845/.* (Accessed: May 31, 2023).

[606] Singh, H. 2012. Final Report, Mass Reduction for Light-Duty Vehicles for Model Years 2017–2025. DOT HS 811 666.; Singh, H. et al. 2018. Mass Reduction for Light-Duty Vehicles for Model Years 2017–2025. DOT HS 812 487.

[607] This analysis applied the cost estimates per pound derived from passenger cars to all passenger car segments, and the cost estimates per pound derived from full-size pickup trucks to all light-duty truck and SUV segments. The cost estimates per pound for carbon fiber (MR5) were the same for all segments.

carbon fiber on their vehicles. For the HDPUV analysis, there is also a significant cost increase from MR1 to MR2. This is because the MR going from MR1 to MR2 in the HDPUV fleet analysis is a larger step than going from MR1 to MR2 for the LD fleet analysis—5% to 7.5% off the glider compared to 1.4% to 13%.

Like past analyses, we considered several options for MR technology costs. Again, we determined that the NHTSA-sponsored studies accounted for significant factors that we believe are important to include our analysis, including materials considerations (material type and gauge, while considering real-world constraints such as manufacturing and assembly methods and complexity), safety (including the Insurance Institute for Highway Safety's (IIHS) small overlap tests), and functional performance (including towing and payload capacity, noise, vibration, and harshness (NVH)), and gradeability in the pickup truck study.

We received comments that the costs used in the analysis to achieve MR5 are high, both because of the way that we calculated MR5 costs, and how we applied updated costs in the model.[608] Regarding the price of carbon fiber technology, considering a 4–5 year time horizon, we believe that our prices are conservative when taking into account rising energy costs to pyrolyze acrylic fibers to carbon fibers and considering all the costs car manufacturers much shoulder on developing processes to turn the dry fibers into reliable structural components. The recent NAS study confirms our pricing.[609] It explicitly indicates an average price (over the time period of interest, 2027–2030) for carbon fiber materials as approximately $8.25 per pound saved and a manufacturing cost for carbon fiber reinforced polymer components of $13 per pound saved. Multiply the sum of these tow numbers by an RPE of 1.5 (direct and indirect and net income) results in roughly $32 per pound saved which is the figure listed in the Technologies Input File used for the CAFE model for 2027.

Regarding the comment that NHTSA misapplied the MR5 costs in the model, on further review NHTSA agrees that not all MR5 pounds saved will be saved with carbon fiber and that cost should be adjusted to include carbon fiber costs proportional to the materials' use in total pounds saved. We would like to investigate using an incremental or bracketed approach (think US tax structure but with pounds saved and cost) in a future analysis where the costs associated with carbon fiber technology will only be applied to the incremental mass reduction in going from one level of MR to another. We did not make that change for this final rule analysis, however. This is a relatively involved change in the model, which we did not have time to implement and QA/QC in the time available to complete the analysis associated with this final rule. That said, we do not believe that this change would result in a significant change in the analysis for the reasons listed below and are comfortable that the analysis associated with this final rule still reasonably represents manufacturer's decision-making, effectiveness, and cost associated with applying the highest levels of mass reduction technology.

First, we limited application of MR5 in the analysis to represent the limited volume of available dry carbon fiber and the resultant high costs of the raw materials. This constraint is described above and in more detail in TSD Chapter 3. The CAFE Model assumes that there is not enough carbon fiber readily available to support vehicle platforms with more than 80,000 vehicles sold per year. We believe this volume constraint does more to limit the application of MR5 technology in the analysis than does its high price. Even if we used a lower price, this dominant constraint would still be volume. Second, we do not believe that that a lower price would prove to be a competitive pathway to compliance for exotic materials technology compared to other less expensive technologies with higher effectiveness. The MR5 effectiveness as applied to the vehicle in this analysis considers the total effect of reducing that level of mass from the vehicle, from the vehicle's starting MR level. As an example, while the cost of going from MR0 or MR1 to MR5 may be slightly overstated (but still limited in total application by the volume cap), the cost of going from MR4 to MR5 is not. NHTSA will continue to consider the balance of carbon fiber and other advanced materials for mass reduction to meet MR5 levels and update that value in future rules.

b. Aerodynamic Improvements

The energy required for a vehicle to overcome wind resistance, or more formally what is known as aerodynamic drag, ranges from minimal at low speeds to incredibly significant at highway speeds.[610] Reducing a vehicle's aerodynamic drag is, therefore, an effective way to reduce the vehicle's fuel consumption. Aerodynamic drag is characterized as proportional to the frontal area (A) of the vehicle and a factor called the coefficient of drag (C_d). The coefficient of drag (C_d) is a dimensionless value that represents a moving object's resistance against air, which depends on the shape of the object and flow conditions. The frontal area (A) is the cross-sectional area of the vehicle as viewed from the front. Aerodynamic drag of a vehicles is often expressed as the product of the two values, C_dA, which is also known as the drag area of a vehicle. The force imposed by aerodynamic drag increases with the square of vehicle velocity, accounting for the largest contribution to road loads at higher speeds.[611]

Manufacturers can reduce aerodynamic drag either by reducing the drag coefficient or reducing vehicle frontal area, which can be achieved by passive or active aerodynamic technologies. Passive aerodynamics refers to aerodynamic attributes that are inherent to the shape and size of the vehicle. Passive attributes can include the shape of the hood, the angle of the windscreen, or even overall vehicle ride height. Active aerodynamics refers to technologies that variably deploy in response to driving conditions. Example of active aerodynamic technologies are grille shutters, active air dams, and active ride height adjustment. Manufacturers may employ both passive and active aerodynamic technologies to improve aerodynamic drag values.

There are four levels of aerodynamic improvement (over AERO0, the first level) available in the LD analysis (AERO5, AERO10, AERO15, AERO20), and two levels of improvements available for the HDPUV analysis (AERO10, AERO20). There are fewer levels available for the HDPUV analysis because HDPUVs have less diversity in overall vehicle shape; prioritization of vehicle functionality forces a boxy shape and limits incorporation of many of the ''shaping''-based aerodynamic technologies, such as smaller side-view mirrors, body air flow, rear diffusers, and so on. Refer back to Figure III–7 and Figure III–8 for a visual of each body style considered in the LD and HDPUV analyses.

Each AERO level associates with 5, 10, 15, or 20 percent aerodynamic drag

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[608] National Resource Defense Council et al., Docket No. NHTSA–2023–0022–61944.

[609] 2021 NAS report, at 7–242–3.

[610] 2015 NAS Report, at 207.

[611] *See, e.g.,* Pannone, G. 2015. Technical Analysis of Vehicle Load Reduction Potential for Advanced Clean Cars, Final Report. April 2015. Available at: *https://ww2.arb.ca.gov/sites/default/files/2020-04/13_313_ac.pdf.* (Accessed: May 31, 2023). The graph on page 20 shows how at higher speeds the aerodyanmic force becomes the dominant load force.

improvement values over a reference value computed for each vehicle body style. These levels, or bins, respectively correspond to the level of aerodynamic drag reduction over the reference value, *e.g.,* ''AERO5'' corresponds to the 5 percent aerodynamic drag improvement value over the reference value, and so on. While each level of aerodynamic drag improvement is technology agnostic—that is, manufacturers can ultimately choose how to reach each level by using whatever technologies work for the vehicle—we estimated a pathway to each technology level based on data from an NRC Canada-sponsored wind tunnel testing program. The program included an extensive review of production vehicles utilizing aerodynamic drag improvement technologies, and industry comments.[612] Our example pathways for achieving each level of aerodynamic drag improvements is discussed in Chapter 3.5 of the TSD.

We assigned aerodynamic drag reduction technology levels in the analysis fleets based on vehicle body styles.[613] We computed an average coefficient of drag based on vehicle body styles, using coefficient of drag data from the MY 2015 analysis fleet for the LD analysis, and data from the MY 2019 Chevy Silverado and MY 2020 Ford Transit and the MY 2022 Ford e-Transit for cargo vans for the HDPUV analysis. Different body styles offer different utility and have varying levels of form drag. This analysis considers both frontal area and body style as unchangeable utility factors affecting aerodynamic forces; therefore, the analysis assumes all reduction in aerodynamic drag forces come from improvement in the drag coefficient. Then we used drag coefficients for each vehicle in the analysis fleet to establish an initial aerodynamic technology level for each vehicle. We compared the vehicle's drag coefficient to the calculated drag coefficient by body style mentioned above, to assign initial levels of aerodynamic drag reduction technology to vehicles in the analysis fleets. We were able to find most vehicles' drag coefficients in manufacturer's publicly available specification sheets; however, in cases where we could not find that information, we used engineering judgment to assign the initial technology level.

We also looked at vehicle body style and vehicle horsepower to determine which types of vehicles can adopt different aerodynamic technology levels. For the LD analysis, AERO15 and AERO20 cannot be applied to minivans, and AERO20 cannot be applied to convertibles, pickup trucks, and wagons. We also did not allow application of AERO15 and AERO20 technology to vehicles with more than 780 horsepower. There are two main types of vehicles that inform this threshold: performance ICE vehicles and high-power BEVs. In the case of the former, we recognize that manufacturers tune aerodynamic features on these vehicles to provide desirable downforce at high speeds and to provide sufficient cooling for the powertrain, rather than reducing drag, resulting in middling drag coefficients despite advanced aerodynamic features. Therefore, manufacturers may have limited ability to improve aerodynamic drag coefficients for high performance vehicles with ICEs without reducing horsepower. Only 4,047 units of sales volume in the analysis fleet include limited application of aerodynamic technologies due to ICE vehicle performance.[614]

In the case of high-power BEVs, the 780-horsepower threshold is set above the highest peak system horsepower present on a BEV in the 2020 fleet. We originally set this threshold based on vehicles in the MY 2020 fleet in parallel with the 780-horsepower ICE limitation. For this analysis, the restriction does not have any functional effect because the only BEVs that have above 780-horsepower in the MY 2022 analysis fleet—the Tesla Model S and X Plaid, and variants of the Lucid Air—are already assigned AERO20 as an initial technology state and there are no additional levels of AERO technology left for those vehicles to adopt. Note that these high horsepower BEVs have extremely large battery packs to meet both performance and range requirements. These bigger battery packs make the vehicles heavier, which means they do not have the same downforce requirements as a similarly situated high-horsepower ICE vehicle. Broadly speaking, BEVs have different aerodynamic behavior and considerations than ICE vehicles, allowing for features such as flat underbodies that significantly reduce drag.[615] BEVs are therefore more likely to achieve higher AERO levels, so the horsepower threshold is set high enough that it does not restrict AERO15 and AERO20 application. BEVs that do not currently use high AERO technology levels are generally bulkier (*e.g.,* SUVs or trucks) or lower budget vehicles.

There are no additional adoption features for aerodynamic improvement technologies in the HDPUV analysis. We limited the range of technology options for reasons discussed above, but both AERO technology levels are available to all HDPUV body styles.

The aerodynamic technology effectiveness values that show the potential fuel consumption improvement from AERO0 technology are found and discussed in Chapter 3.5.4 of the TSD. For example, the AERO20 values shown represent the range of potential fuel consumption improvement values that could be achieved through the replacement of AERO0 technology with AERO20 technology for every technology key that is not restricted from using AERO20. We use the change in fuel consumption values between entire technology keys and not the individual technology effectiveness values. Using the change between whole technology keys captures the complementary or non-complementary interactions among technologies.

We carried forward the established AERO technology costs previously used in the 2020 final rule and again into the MY 2024–2026 standards analysis,[616] and updated those costs to the dollar-year used in this analysis. For LD AERO improvements, the cost to achieve AERO5 is relatively low, as manufacturers can make most of the improvements through body styling changes. The cost to achieve AERO10 is higher than AERO5, due to the addition of several passive aerodynamic technologies, and consecutively the cost to achieve AERO15 and AERO20 are much higher than AERO10 due to use of both passive and active aerodynamic technologies. The two AERO technology levels available for HDPUVs are similar in technology type and application to LDVs in the same technology categories, specifically light trucks. Because of this similarity, and unlike other technology areas that are required to handle higher loads or greater wear, aerodynamics technologies can be almost directly ported between fleets. As a result, there is no difference in technology cost

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[612] Larose, G. et al. 2016. Evaluation of the Aerodynamics of Drag Reduction Technologies for Light-duty Vehicles—a Comprehensive Wind Tunnel Study. *SAE International Journal of Passenger Cars—Mechanical Systems.* Vol.9(2): at 772–784. Available at: *https://doi.org/10.4271/2016-01-1613.* (Accessed: May 31, 2023).

[613] These assignments do not necessarily match the body styles that manufacturers use for marketing purposes. Instead, we make these assignments based on engineering judgment and the categories used in our modeling, considering how this affects a vehicle's AERO and vehicle technology class assignments.

[614] See the Market Data Input File.

[615] 2020 EPA Automotive Trends Report, at 227.

[616] See the FRIA accompanying the 2020 final rule, Chapter VI.C.5.e.

between LD and HDPUV fleets for this analysis. The cost estimates are based on CBI submitted by the automotive industry in advance of the 2018 CAFE NPRM, and on our assessment of manufacturing costs for specific aerodynamic technologies. See the 2018 FRIA for discussion of the cost estimates.[617] We received no additional comments from stakeholders regarding the costs established in the 2018 FRIA during the MY 2024–2026 standards analysis and continued to use the established costs for this analysis. TSD Chapter 3.5 contains additional discussion of aerodynamic improvement technology costs, and costs for all technology classes across all MYs are in the CAFE Model's Technologies Input File. We received no additional comments on aerodynamics technologies and costs and continue to use the established costs for this final rule analysis.

c. Low Rolling Resistance Tires

Tire rolling resistance burns additional fuel when driving. As a car or truck tire rolls, at the point the tread touches the pavement, the tire flattens-out to create what tire engineers call the contact patch. The rubber in the contact patch deforms to mold to the tiny peaks and valleys of the payment. The interlock between the rubber and these tiny peaks and valleys creates grip. Every time the contact patch leaves the road surface as the tire rotates, it must recover to its original shape and then as the tire goes all the way around it must create a new contact patch that molds to a new piece of road surface. However, this molding and repeated re-molding action takes energy. Just like when a person stretches a rubber band it takes work, so does deforming the rubber and the tire to form the contact patch. When thinking about the efficiency of driving a car down the road, this means that not all the energy produced by a vehicle's engine can go into propelling the vehicle forward. Instead, some small, but appreciable, amount goes into deforming the tire and creating the contact patch repeatedly. This also explains why tires with low pressure have higher rolling resistance than properly inflated tires. When the tire pressure is low, the tire deforms more to create the contact patch which is the same as stretching the rubber farther in the analogy above. The larger deformations burn up even more energy and results in worse fuel mileage. Lower-rolling-resistance tires have characteristics that reduce frictional losses associated with the energy dissipated mainly in the deformation of the tires under load, thereby improving fuel economy.

We use three levels of low rolling resistance tire technology for LDVs and two levels for HDPUVs. Each level of low rolling resistance tire technology reduces rolling resistance by 10 percent from an industry-average rolling resistance coefficient (RRC) value of 0.009.[618] While the industry-average RRC is based on information from LDVs, we also determined that value is appropriate for HDPUVs. RRC data from a NHTSA-sponsored study shows that similar vehicles across the LD and HDPUV categories have been able to achieve similar RRC improvements. See Chapter 3.6 of the TSD for more information on this comparison. TSD Chapter 3.6.1 shows the LD and HDPUV low rolling resistance technology options and their associated RRC.

We have been using ROLL10 and ROLL20 in the last several CAFE Model analyses. New for this analysis is ROLL30 for the LD fleet. In past rulemakings, we did not consider ROLL30 due to lack of widespread commercial adoption of ROLL30 tires in the fleet within the rulemaking timeframe, despite commenters' argument on availability of the technology on current vehicle models and possibility that there would be additional tire improvements over the next decade.[619] Comments we received during the comment period for the last CAFE rule also reflected the application of ROLL30 by OEMs, although they discouraged considering the technology due to high cost and possible wet traction reduction. With increasing use of ROLL30 application by OEMs,[620] and material selection making it possible to design low rolling resistance independent of tire wet grip (discussed in detail in Chapter 3.6 of the TSD), we now consider ROLL30 as a viable future technology during this rulemaking period. We believe that the tire industry is in the process of moving automotive manufacturers towards higher levels of rolling resistance technology in the vehicle fleet. We believe that at this time, the emerging tire technologies that would achieve 30 percent improvement in rolling resistance, like changing tire profile, stiffening tire walls, novel synthetic rubber compounds, or adopting improved tires along with active chassis control, among other technologies, will be available for commercial adoption in the fleet during this rulemaking timeframe.

However, we did not consider ROLL30 for the HDPUV fleet, for several reasons. We do not believe that HDPUV manufacturers will use ROLL30 tires because of the significant added cost for the technology while they would see more fuel efficiency benefits from powertrain improvements. As discussed further below, our cost estimates for ROLL30 technology—which incorporate both technology and materials costs—are approximately double the costs of ROLL20. In addition, a significant majority of the HDPUV fleet currently employs no low rolling resistance tire technology. We believe that HDPUV manufacturers will still move through ROLL10 and ROLL20 technology in the rulemaking timeframe. For the final rule, we did not receive feedback from commenters regarding using ROLL30 for HDPUVs. We finalized this rulemaking analysis without including ROLL30 for the HDPUV fleet.

Assigning low rolling resistance tire technology to the analysis fleet is difficult because RRC data is not part of tire manufacturers' publicly released specifications, and because vehicle manufacturers often offer multiple wheel and tire packages for the same nameplate. Consistent with previous rules, we used a combination of CBI data, data from a NHTSA-sponsored ROLL study, and assumptions about parts-sharing to assign tire technology in the analysis fleet. A slight majority of vehicles (52.9%) in the LD analysis fleet do not use any ROLL improvement technology, while 16.2% of vehicles use ROLL10 and 24.9% of vehicles use ROLL20. Only 6% of vehicles in the LD analysis fleet use ROLL30. Most (74.5%) vehicles in the HDPUV analysis fleet do

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[617] See the PRIA accompanying the 2018 NPRM, Chapter 6.3.10.1.2.1.2 for a discussion of these cost estimates.

[618] See Technical Analysis of Vehicle Load Reduction by CONTROLTEC for California Air Resources Board (April 29, 2015). We determined the industry-average baseline RRC using a CONTROLTEC study prepared for the CARB, in addition to considering CBI submitted by vehicle manufacturers prior to the 2018 LD NPRM analysis. The RRC values used in this study were a combination of manufacturer information, estimates from coast down tests for some vehicles, and application of tire RRC values across other vehicles on the same platform. The average RRC from surveying 1,358 vehicle models by the CONTROLTEC study is 0.009. The CONTROLTEC study compared the findings of their survey with values provided by the U.S. Tire Manufacturers Association for original equipment tires. The average RRC from the data provided by the U.S. Tire Manufacturers Association is 0.0092, compared to the average of 0.009 from CONTROLTEC.

[619] NHTSA–2018–0067–11985.

[620] Docket No. NHTSA–2021–0053–0010, Evaluation of Rolling Resistance and Wet Grip Performance of OEM Stock Tires Obtained from NCAP Crash Tested Vehicles Phase One and Two, Memo to Docket—Rolling Resistance Phase One and Two; Technical Analysis of Vehicle Load Reduction by CONTROLTEC for California Air Resources Board (April 29, 2015); NHTSA DOT HS 811 154.

not use any ROLL improvement technology, and 3.0% and 22.5% use ROLL10 and ROLL20, respectively.

The CAFE Model can apply ROLL technology at either a vehicle refresh or redesign. We recognize that some vehicle manufacturers prefer to use higher RRC tires on some performance cars and SUVs. Since most of performance cars have higher torque, to avoid tire slip, OEMs prefer to use higher RRC tires for these vehicles. Like the aerodynamic technology improvements discussed above, we applied ROLL technology adoption features based on vehicle horsepower and body style. All vehicles in the LD and HDPUV fleets that have below 350hp can adopt all levels of ROLL technology.

TSD Chapter 3.6.3 shows that all LDVs under 350 hp can adopt ROLL technology, and as vehicle hp increases, fewer vehicles can adopt the highest levels of ROLL technology. Note that ROLL30 is not available for vehicles in the HDPUV fleet not because of an adoption feature, but because it is not included in the ROLL technology pathway.

TSD Chapter 3.6 shows how effective the different levels of ROLL technology are at improving vehicle fuel consumption.

DMCs and learning rates for ROLL10 and ROLL20 are the same as prior analyses,[621] but are updated to the dollar-year used in this analysis. In the absence of ROLL30 DMCs from tire manufacturers, vehicle manufacturers, or studies, to develop the DMC for ROLL30 we extrapolated the DMCs for ROLL10 and ROLL20. In addition, we used the same DMCs for the LD and HDPUV analyses. This is because the original cost of a potentially heaver or sturdier HDPUV tire is already accounted for in the initial MSRP of a HDPUV in our analysis fleet, and the DMC represents the added cost of the improved tire technology. In addition, as discussed above, LD and HDPUV tires are often interchangeable. We believe that the added cost of each tire technology accurately represents the price difference that would be experienced by the different fleets. ROLL technology costs are discussed in detail in Chapter 3.6 of the TSD, and ROLL technology costs for all vehicle technology classes can be found in the CAFE Model's Technologies Input File. We did not receive comments on this approach used for this analysis and so we finalized the NPRM approach for the final rule.

5. Simulating Air Conditioning Efficiency and Off-Cycle Technologies

Off-cycle and AC efficiency technologies can provide fuel economy benefits in real-world vehicle operation, but the traditional 2-cycle test procedures (*i.e.,* FTP and HFET) used to measure fuel economy cannot fully capture those benefits.[622] Off-cycle technologies can include, but are not limited to, thermal control technologies, high-efficiency alternators, and high-efficiency exterior lighting. As an example, manufacturers can claim a benefit for thermal control technologies like active seat ventilation and solar reflective surface coating, which help to regulate the temperature within the vehicle's cabin—making it more comfortable for the occupants and reducing the use of low-efficiency heating, ventilation, and air-conditioning (HVAC) systems. AC efficiency technologies are technologies that reduce the operation of or the loads on the compressor, which pressurizes AC refrigerant. The less the compressor operates or the more efficiently it operates, the less load the compressor places on the engine or battery storage system, resulting in better fuel efficiency. AC efficiency technologies can include, but are not limited to, blower motor controls, internal heat exchangers, and improved condensers/evaporators.

Vehicle manufacturers have the option to generate credits for off-cycle technologies and improved AC systems under the EPA's CO_2 program and receive a fuel consumption improvement value (FCIV) equal to the value of the benefit not captured on the 2-cycle test under NHTSA's CAFE program. The FCIV is not a ''credit'' in the NHTSA CAFE program—unlike, for example, the statutory overcompliance credits prescribed in 49 U.S.C. 32903—but FCIVs increase the reported fuel economy of a manufacturer's fleet, which is used to determine compliance. EPA applies FCIVs during determination of a fleet's final average fuel economy reported to NHTSA.[623] We only calculate and apply FCIVs at a manufacturer's fleet level, and the improvement is based on the volume of the manufacturer's fleet that contains qualifying technologies.

We currently do not model AC efficiency and off-cycle technologies in the CAFE Model like we model other vehicle technologies, for several reasons. Each time we add a technology option to the CAFE Model's technology pathways we increase the number of Autonomie simulations by approximately a hundred thousand. This means that to add just five AC efficiency and five off-cycle technology options would double our Autonomie simulations to around two million total simulations. In addition, 40 CFR 600.512–12 does not require manufacturers to submit information regarding AC efficiency and off-cycle technologies on individual vehicle models in their FMY reports to EPA and NHTSA.[624] In their FMY reports, manufacturers are only required to provide information about AC efficiency and off-cycle technology application at the fleet level. However, starting with MY 2023, manufacturers are required to submit AC efficiency and off-cycle technology data to NHTSA in the new CAFE Projections Reporting Template for PMY, MMY and supplementary reports. Once we begin evaluating manufacturer submissions in the CAFE Projections Reporting Template we may reconsider how off-cycle and AC efficiency technologies are evaluated in future analysis. However, developing a robust methodology for including off-cycle and AC efficiency technologies in the analysis depends on manufacturers giving us robust data.

Instead, the CAFE Model applies predetermined AC efficiency and off-cycle benefits to each manufacturer's fleet after the CAFE Model applies traditional technology pathway options. The CAFE Model attempts to apply pathway technologies and AC efficiency

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[621] See NRC/NAS Special Report 286, Tires and Passenger Vehicle Fuel Economy: Informing Consumers, Improving Performance (2006); Corporate Average Fuel Economy for MY 2011 Passenger Cars and Light Trucks, Final Regulatory Impact Analysis (March 2009), at V–137; Joint Technical Support Document: Rulemaking to Establish Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards (April 2010), at 3–77; Draft Technical Assessment Report: Midterm Evaluation of Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards for Model Years 2022–2025 (July 2016), at 5–153 and 154, 5–419. In brief, the estimates for ROLL10 are based on the incremental $5 value for four tires and a spare tire in the NAS/NRC Special Report and confidential manufacturer comments that provided a wide range of cost estimates. The estimates for ROLL20 are based on incremental interpolated ROLL10 costs for four tires (as NHTSA and EPA believed that ROLL20 technology would not be used for the spare tire), and were seen to be generally fairly consistent with CBI suggestions by tire suppliers.

[622] Pursuant to 49 U.S.C 32904(c), the Administrator of the EPA must measure fuel economy for each model and calculate average fuel economy for a manufacturer under testing and calculation procedures prescribed by the Administrator. The Administrator is required to use the same procedures for passenger automobiles used for model year 1975 (weighted 55 percent urban cycle and 45 percent highway cycle), or procedures that give comparable results.

[623] 49 U.S.C. 32904. Under EPCA, the Administrator of the EPA is responsible for calculating and measuring vehicle fuel economy.

[624] 40 CFR 600.512–12.

and off-cycle technologies in a way that both minimizes cost and allows the manufacturer to meet a given CAFE standard without over or under complying. The predetermined benefits that the CAFE Model applies for AC efficiency and off-cycle technologies are based on EPA's 2022 Trends Report and CBI compliance data from vehicle manufacturers. We started with each manufacturer's latest reported values and extrapolated the values to the regulatory cap for benefits that manufacturers are allowed to claim, considering each manufacturer's fleet composition (*i.e.,* passenger cars versus light trucks) and historic AC efficiency and off-cycle technology use. In general, data shows that manufacturers apply less off-cycle technology to passenger cars than pickup trucks, and our input assumptions reflect that. Additional details about how we determined AC efficiency and off-cycle technology application rates are discussed Chapter 3.7 of the TSD.

New for this rulemaking cycle, we also developed a methodology for considering BEV AC efficiency and off-cycle technology application when estimating the maximum achievable credit values for each manufacturer. We did this because the analytical ''no-action'' reference baseline against which we measure the costs and benefits of our standards includes an appreciable number of BEVs. Because BEVs are not equipped with a traditional engine or transmission, they cannot benefit from off-cycle technologies like engine idle start-stop, active transmission and engine warm-up, and high efficiency alternator technologies. However, BEVs still benefit from technologies like high efficiency lighting, solar panels, active aerodynamic improvement technologies, and thermal control technologies. We calculated the maximum off-cycle benefit that the model could apply for each manufacturer and each MY based on off-cycle technologies that could be applied to BEVs and the percentage of BEVs in each manufacturer's fleet. Note that we do not include PHEVs in this calculation, because they still use a conventional ICE and manufacturers are not required to report UF estimates for individual vehicles, which would have made partial estimation for off-cycle and AC efficiency benefits at the fleet level very difficult. However, we do think that this is reasonable because PHEVs overall constitute less than 2% of the current fleet and the off-cycle and AC efficiency FCIVs for those vehicles only receive a fractional benefit.[625] We discuss additional details and assumptions for this calculation in Chapter 3.7 of the Final TSD.

Note also that we do not model AC efficiency and off-cycle technology benefits for HDPUVs. We have received petitions for off-cycle benefits for HDPUVs from manufacturers, but to date, none have been approved.

Because the CAFE Model applies AC efficiency and off-cycle technology benefits independent of the technology pathways, we must account for the costs of those technologies independently as well. We generated costs for these technologies on a dollars per gram of CO_2 per mile ($ per g/mi) basis, as AC efficiency and off-cycle technology benefits are applied in the CAFE Model on a gram per mile basis (as in the regulations). For this final rule, we updated our AC efficiency and off-cycle technology costs by implementing an updated calculation methodology and converting the DMCs to 2021 dollars. The AC efficiency costs are based on data from EPA's 2010 Final Regulatory Impact Analysis (FRIA) and the 2010 and 2012 Joint NHTSA/EPA TSDs.[626] [627] [628] We used data from EPA's 2016 Proposed Determination TSD [629] to develop the updated off-cycle costs that were used for the 2022 final rule and now this final rule. Additional details and assumptions used for AC efficiency and off-cycle costs are discussed in Chapter 3.7.2 of the Final TSD.

We received limited comments on how we model off-cycle and AC efficiency FCIVs for this rulemaking analysis.[630] [631] Mitsubishi commented that the differences between NHTSA and EPA's proposed rules, ''would force manufacturers to choose between applying off-cycle technologies that only apply to the CAFE standard or on-cycle technologies—which are potentially more expensive—that would apply to both the GHG and CAFE standards. NHTSA should model the effects of the EPA GHG proposal on the adoption of off-cycle technology to avoid overestimating the industry's ability to comply, and underestimating the cost of compliance.'' The Alliance commented that ''for MYs 2023 through 2026 the limit is 15 g/mile on . . . passenger car and trucks fleets. For all other years it is currently 10 g/mile. NHTSA's modeling of off-cycle credits frequently exceeds the 10 g/mile cap in MYs 2027 and later. Assuming NHTSA intends manufacturers to follow the caps defined by EPA, it should correct its modeling so that off-cycle credits are limited to the capped amount.''

We agree with Mitsubishi's comment that differences between the proposed changes to our off-cycle program and EPA's proposed changes to its program could make it difficult for manufacturers to select which off-cycle technologies to place on the vehicles in their compliance fleets. We also agree with the Alliance that, in our modeling for the NPRM, the off-cycle caps exceeded the limits established in the regulation. For this final rule, to align with EPA, NHTSA has changed its proposed limit on the number of off-cycle FCIVs available to manufacturers in MYs 2027 through 2050 in our modeling. For passenger cars powered by an internal combustion engine, we changed the off-cycle FCIV limit from 10.0 g/mi in MYs 2030 through 2050 to 8.0 g/mi in MY 2031, 6.0 g/mi in MY 2032, and 0 g/mi in MYs 2033 through 2050. For light trucks powered by an internal combustion engine, we changed the off-cycle FCIV limit from 15.0 g/mi in MYs 2027 through 2050 to 10.0 g/mi in MYs 2027 through 2030, 8.0 g/mi in MY 2031, 6.0 g/mi in MY 2032, and 0 g/mi in MYs 2033 through 2050. Starting in MY 2027, BEVs will no longer be eligible for off-cycle FCIVs in the CAFE program. To facilitate this, we set the off-cycle FCIV limit for BEVs in both the passenger car and light truck regulatory categories to 0 g/mi for MYs 2027 through 2050.

The Alliance also commented that NHTSA proposed to eliminate AC efficiency FCIVs for BEVs beginning in MY 2027 but allowed the credit caps set prior to MY 2027 to be carried forward through MY 2050. They stated that if NHTSA finalizes its proposal to eliminate AC efficiency FCIVs for BEVs, it should adjust its modeling to reflect that.

We agree with the commenter that, in our proposal, we did not model the elimination of AC efficiency FCIVs for

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[625] For example, if UF of a PHEV is esitmated oepration to be 30% ICE and 70% electric than the benefit of Off-cycle and AC efficiecny would only apply to the ICE portiona only.

[626] Final Rulemaking to Establish Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards Regulatory Impact Analysis for MYs 2012–2016.

[627] Final Rulemaking to Establish Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards Joint Technical Support Document for MYs 2012–2016.

[628] Joint Technical Support Document: Final Rulemaking for 2017–2025 Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards.

[629] Proposed Determination on the Appropriateness of the Model Year 2022–2025 Light-Duty Vehicle Greenhouse Gas Emissions Standards under the Midterm Evaluation: Technical Support Document.

[630] Mitsubishi, Docket No. NHTSA–2023–0022–61637.

[631] The Alliance, Docket No. NHTSA–2023–0022–60652–A3.

BEVs in MYs 2027 through 2050. However, we have corrected this error in our modeling for the final rule. Starting in MY 2027, BEVs will no longer be eligible for AC efficiency FCIVs in the CAFE program. To facilitate this, we set the AC efficiency credit limit for BEVs in both the passenger car and light truck regulatory categories to 0 g/mi for MYs 2027 through 2050 in our modeling.

E. Consumer Responses to Manufacturer Compliance Strategies

Previous subsections of Section III have so far discussed how manufacturers might respond to changes in the standards. While the technology analysis outlined different compliance strategies available to manufacturers, the tangible costs and benefits that accrue because of the standards also depend on how consumers respond to manufacturers decisions. Some of the benefits and costs resulting from changes to standards are private benefits that accrue to the buyers of new vehicles, produced in the MYs under consideration. These benefits and costs largely flow from changes to vehicle ownership and operating costs that result from improved fuel economy, and the costs of the technologies required to achieve those improvements. The remaining benefits are also derived from how consumers use—or do not use—vehicles, but because these are experienced by the broader public rather than borne directly by consumers who purchase and drive new vehicles, we categorize these as ''external'' benefits even when they do not meet the formal economic definition of externalities. The next few subsections outline how the agency's analysis models consumers' responses to changes in vehicles implemented by manufacturers to respond to the CAFE and HDPUV standards.

1. Macroeconomic and Consumer Behavior Assumptions

Most economic effects of the new standards this final rule establishes are influenced by macroeconomic conditions that are outside the agency's influence. For example, fuel prices are mainly determined by global petroleum supply and demand, yet they partially determine how much fuel efficiency-improving technology U.S. manufacturers will apply to their vehicles, how much more consumers are willing to pay to purchase models offering higher fuel economy or efficiency, how much buyers decide to drive them, and the value of each gallon of fuel saved from higher standards. Constructing these forecasts requires robust projections of demographic and macroeconomic variables that span the full timeframe of the analysis, including real GDP, consumer confidence, U.S. population, and real disposable personal income.

The analysis presented with this final rule employs fuel price forecasts developed by the U.S. Energy Information Administration (EIA), an agency within the U.S. DOE which collects, analyzes, and disseminates independent and impartial energy information to promote sound policymaking and public understanding of energy and its interaction with the economy and the environment. EIA uses its National Energy Modeling System (NEMS) to produce its Annual Energy Outlook (AEO), which presents forecasts of future fuel prices among many other economic and energy-related variables, and these are the source of some inputs to the agency's analysis. NHTSA noted in its proposal that it was considering updating the inputs used to analyze this final rule to include projections from the 2023 AEO for its final rule, and the California Attorney General and others commented that NHTSA should make this change. The agency's analysis of this final rule uses the 2023 EIA AEO's forecasts of U.S. population, GDP, disposable personal income, GDP deflator, fuel prices and electricity prices.[632]

The analysis also relies on S&P Global's forecasts of total the number of U.S. households, and the University of Michigan's Consumer Confidence Index from its annual Global Economic Outlook, which EIA also uses to develop the projections it reports in its AEO.

While these macroeconomic assumptions are important inputs to the analysis, they are also uncertain, particularly over the long lifetimes of the vehicles affected by this final rule. To reflect the effects of this uncertainty, the agency also uses forecasts of fuel prices from AEO's Low Oil Price and High Oil Price side cases to analyze the sensitivity of its analysis to alternative fuel price projections. The purpose of the sensitivity analyses, discussed in greater detail in Chapter 9 of the FRIA, is to measure the degree to which important outcomes can change under different assumptions about fuel prices. NHTSA similarly uses low and high growth cases from the AEO as bounding cases for the macroeconomic variables in its analysis.

Some commenters argued that electricity prices charged to users of public charging stations are somewhat higher on average than the residential rates in AEO 2023.[633] NHTSA expects that at-home charging will continue to be the primary charging method, and thus residential electricity rates are the most representative electricity prices to use in our analysis, and the CAFE Model as currently constructed cannot differentiate between residential and public charging.

The first year included in this analysis is model year 2022, and data for that year represent actual observations rather than forecasts to the extent possible. The projected macroeconomic inputs used in this analysis as well as the forecasts that depend on them—aggregate demand for driving, new vehicle sales, and used vehicle retirement rates—reflect a continued return to pre-pandemic growth rates under all regulatory alternatives. See Chapter 4.1 of the TSD for a more complete discussion of the macroeconomic forecasts and assumptions used in this analysis.

Another key assumption that permeates the agency's analysis is how much consumers are willing to pay for improved fuel economy. Increased fuel economy offers vehicle owners savings through reduced fuel expenditures throughout the lifetime of a vehicle. If buyers fully value the savings in fuel costs that result from driving (and potentially re-selling) vehicles with higher fuel economy, and manufacturers supply all improvements in fuel economy that buyers demand, then market-determined levels of fuel economy would reflect both the cost of improving it and the private benefits from doing so. In that case, regulations on fuel economy would only be necessary to reflect environmental or other benefits not experienced by buyers themselves. But if consumers instead undervalue future fuel savings or appear unwilling to purchase cost-minimizing levels of fuel economy for other reasons, manufacturers would spend too little on fuel-saving technology (or deploy its energy-saving benefits to improve vehicles' other attributes). In that case, more stringent fuel economy standards could lead manufacturers to make improvements in fuel economy that not only reduce external costs from producing and consuming fuel, but also improve consumer welfare.

Increased fuel economy offers vehicle owners significant potential savings. The analysis shows that the value of prospective fuel savings exceeds manufacturers' technology costs to comply with the preferred alternatives

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[632] States and Cities, Docket No. NHTSA–2023–0022–61904, at 27.

[633] NATSO et al., Docket No. NHTSA–2023–0022–61070, at 7–8.

for each regulatory class when discounted at 3 percent. It seems reasonable to assume that well-informed vehicle shoppers who do not face time constraints or other barriers to economically rational decision-making will recognize the full value of fuel savings from purchasing a model that offers higher fuel economy, since they would be compensated with an equivalent increase in their disposable income and the other consumption opportunities it affords them. For commercial operators, higher fuel efficiency and the reduced fuel costs it provides would free up additional capital for either higher profits or additional business ventures. If consumers did value the full amount of fuel savings, more fuel-efficient vehicles would functionally be less costly for consumers to own when considering both their purchase prices and subsequent operating costs, thus making the models that manufacturers are likely to offer under stricter alternatives more attractive than those available under the No-Action Alternative.

Recent econometric research is inconclusive. Some studies conclude that consumers value most or all of the potential savings in fuel costs from driving higher-mpg vehicles, and others conclude that consumers significantly undervalue expected fuel savings. More circumstantial evidence appears to show that consumers do not fully value the expected lifetime fuel savings from purchasing higher-mpg models. Although the average fuel economy of new light vehicles reached an all-time high in MY 2021 of 25.4 mpg,[634] this is still significantly below the fuel economy of the fleet's most efficient vehicles that are readily available to consumers.[635] Manufacturers have repeatedly informed the agency that consumers only value between 2 to 3 years of fuel savings when choosing among competing models to purchase.

The potential for buyers to forego improvements in fuel economy that appear to offer future savings exceeding their initial costs is one example of what is often termed the ''energy paradox'' or ''energy-efficiency gap.'' This appearance of a gap between the level of energy efficiency that would minimize consumers' overall expenses and the level they choose to purchase is typically based on engineering calculations that compare the initial cost for providing higher energy efficiency to the discounted present value of the resulting savings in future energy costs. There has long been an active debate about whether such a gap actually exists and why it might arise. Economic theory predicts, assuming perfect information and absent market failures, that economically rational individuals will purchase more energy-efficient products only if the savings in future energy costs they offer promise to offset their higher initial purchase cost.

However, the field of behavioral economics has documented situations in which the decision-making of consumers can differ from what the standard model of rational consumer behavior predicts, particularly when the choices facing consumers involve uncertain outcomes.[636] The future value of purchasing a vehicle that offers higher fuel economy is inherently uncertain for many reasons, but particularly because the mileage any particular driver experiences will differ from that shown on fuel economy labels, potential buyers may be uncertain how much they will actually drive a new vehicle, future resale prices may be unpredictable, and future fuel prices are highly uncertain. Recent research indicates that some consumers exhibit several departures from purely rational economic behavior, some of which could account for undervaluation of fuel economy to an extent roughly consistent with the agency's assumed 30-month payback rule. These include valuing potential losses more than potential gains of equal value when faced with an uncertain choice (''loss aversion''), the tendency to apply discount rates that decrease over time (''present bias,'' also known as hyperbolic discounting), a preference for choices with certain rather than uncertain outcomes (''certainty bias''), and inattention or ''satisficing.''[637]

There are also a variety of more conventional explanations for why consumers might not be willing to pay the cost of improvements in fuel efficiency that deliver net savings, including informational asymmetries among consumers, dealerships, and manufacturers; market power; first-mover disadvantages for both consumers and manufacturers; principal-agent problems that create differences between the incentives of vehicle purchasers and vehicle drivers; and positional externalities.[638]

The proposal assumed that potential buyers value only the undiscounted savings in fuel costs from purchasing a higher-mpg model they expect to realize over the first 30 months (*i.e.,* 2.5 years) they own it. NHTSA sought comment on the 30-month payback period assumption in its proposal. IPI agreed with NHTSA's choice to include the energy efficiency gap as a potential cause for why consumers may not fully value fuel savings in their purchase decisions.[639] IPI also suggested that NHTSA's discussion of the energy efficiency gap omitted relevant findings from the literature and expressed undue uncertainty regarding the existence of the gap. Consumer Reports suggested that NHTSA should continue to rely on a shorter payback period when modeling how much fuel savings manufacturers believe consumers will value but use a longer payback period to represent consumers preferences.

Valero commented and suggested that NHTSA's 30-month payback assumption is ''unsupported,'' and that in the proposal's No-Action case a large number of vehicle models were converted to BEVs with payback periods longer than 30 months.[640] The Center for Environmental Accountability suggested that manufacturers have *not* supported the 30-month payback period and have instead stated that consumers do not display any myopic tendencies. They suggested NHTSA should switch from a 30-month assumption to a more conservative and longer payback period and pointed towards the lower net benefits found in the proposal's 60-month payback period sensitivity case as evidence that this would lower net benefits from the preferred alternative, in some cases causing them to become negative.[641]

Although commenters expressed dissatisfaction with NHTSA's assumption and proposed various alternatives to it, NHTSA ultimately decided to continue using its methodology from the proposal in its final rule analysis. In preparation for the final rule, NHTSA updated its review of research on the energy efficiency gap, concluding that estimates of how

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[634] See EPA 2022 Automotive Trends Report at 5. Available at *https://www.epa.gov/system/files/documents/2022-12/420r22029.pdf.* (Accessed: Feb. 27, 2024).

[635] *Id.* at 9.

[636] E.g. Dellavigna, S. 2009. Psychology and Economics: Evidence from the Field. *Journal of Economic Literature.* 47(2): at 315–372.

[637] Satisficing is when a consumer finds a solution that meets enough of their requirements instead of searching for a vehicle that optimizes their utility.

[638] For a discussion of these potential market failures, *see* Rothschild, R., Schwartz, J. 2021. Tune Up: Fixing Market Failures to Cut Fuel Costs and Pollution from Cars and Trucks. IPI. New York University School of Law.

[639] IPI, Docket No. NHTSA–2023–0022–60485, at. 2, 31–32.

[640] Valero, Docket No. NHTSA–2023–0022–58547, at 10.

[641] CEA, Docket No. NHTSA–2023–0022–61918, at 18.

consumers value fuel savings reported in recent published literature continue to show a wide range, and updated its discussion of this topic in Chapter 2.4 of the FRIA to reflect this finding. While survey data like the results that Consumer Reports submitted are suggestive of a broad appeal for fuel savings among consumers, they represent the stated preferences of respondents for *some increased level* of fuel economy and may not accurately describe their actual purchasing behavior when faced with the range of fuel economy levels in today's new vehicle market. In fact, previous surveys performed by Consumer Reports show that a significantly smaller fraction—29%—of those who are willing to pay for increased fuel economy would be willing to pay for improvements that required longer than 3 years to repay the higher costs of purchasing models that offered them, with the average consumer willing to pay only for fuel economy improvements that recouped their upfront costs within 2 to 3 years.[642]

In response to Valero and the Center for Environmental accountability, NHTSA disagrees that its methodology is unsupported. This assumption is based on what manufacturers have told NHTSA they believe to be consumers' willingness to pay, and this belief is ultimately what determines the amount of technology that manufacturers will freely adopt. The Center for Environmental Accountability seems to misconstrue comments submitted by the Alliance to the revised Circular A–4 proposal, which explores the possibility that consumers value most if not all fuel savings at higher personal discount rates. The Alliance's comment to OMB mirrors the language included in the proposal's TSD, and as the agency found in the proposal and again for this final rule, is not incongruent with the 30-month payback assumption, as explained in Chapter 2.4 of the FRIA. The Alliance's comment to OMB also cites a recent paper by Leard (2023) which found higher willingness to pay for fuel economy improvements. NHTSA considered and referenced this same paper alongside other recent research in its own evaluation of the literature in the proposal and in the final rule. Furthermore, the Alliance has traditionally supported a 30-month payback assumption for the central analysis.[643]

NHTSA did not choose to adopt separate assumptions about consumer willingness to pay for fuel savings in its sales and technology modules for the final rule. As profit maximizing firms, manufacturers have a strong interest in producing vehicles with the attributes that consumers will most value. Indeed, the EPA trends report finds that in 2022 the 90th percentile real-world fuel economy for the fleet of new vehicles was over 3 times the median value.[644] If fuel economy was valued by consumers at a significantly higher rate than manufacturers believe that they value it, then presumably these high fuel economy vehicles would have severe excess demand and inventory for them would be incredibly scarce, which NHTSA does not observe in the data.[645] NHTSA would need more compelling evidence about the market failures that would lead manufacturers to consistently incorrectly assess the willingness to pay of consumers for fuel savings. NHTSA believes that without such evidence, the approach from the proposal is a more reasonable method for modeling this variable.

The 30-month payback period assumption also has important implications for other results of our regulatory analysis, including the effect of raising standards on sales and use of new vehicles, the number and use of older vehicles, safety, and emissions of air pollutants. Recognizing the consequences of these effects for our regulatory analysis, NHTSA also includes a handful of sensitivity cases to examine the impacts of longer and shorter payback periods on its outcomes. These concepts are explored more thoroughly in Chapter 4.2.1.1 of the TSD and Chapter 2.4 of the FRIA.

It is possible that buyers of vehicles used in commercial or business enterprises, who presumably act as profit-maximizing entities, could value tradeoffs between long-term fuel savings and initial purchase prices differently than the average non-commercial consumer. However, both commercial and non-commercial consumers face their own sources of uncertainty or other constraints that may prevent them from purchasing levels of fuel efficiency that maximize their private net benefits. Additionally, the CAFE Model is unable to distinguish between these two types of purchasers. Given this constraint, NHTSA believes that using the same payback period for the HDPUV fleet as for the LD fleet continues to make sense. Similar to the light-duty analysis, the agency is including several sensitivity cases testing alternative payback assumptions for HDPUVs. One commenter noted that switching to a 60-month payback period in its sensitivity case caused net benefits to become negative.[646] NHTSA acknowledged the sensitivity of this result in the proposal but believes that for the reasons noted above, that a 30 month payback period is still a better supported choice for modelling HDPUV buyers' payback period within the constraints of the CAFE Model.

2. Fleet Composition

The composition of the on-road fleet—and how it changes in response to establishing higher CAFE and fuel efficiency standards—determines many of the costs and benefits of the final rule. For example, how much fuel the LD fleet consumes depends on the number and efficiency of new vehicles sold, how rapidly older (and less efficient) vehicles are retired, and how much the vehicles of each age that remain in use are driven.

Until the 2020 final rule, previous CAFE rulemaking analyses used static fleet forecasts that were based on a combination of manufacturer compliance data, public data sources, and proprietary forecasts (or product plans submitted by manufacturers). When simulating compliance with regulatory alternatives, those analyses projected identical sales and retirements for each manufacturer and model under every regulatory alternative. Exactly the same number of each model was assumed to be sold in a given MY under both the least stringent alternative (typically the reference baseline) and the most stringent alternative considered (intended to represent ''maximum technology'' scenarios in some cases).

However, a static fleet forecast is unlikely to be representative of a broad set of regulatory alternatives that feature significant variation in prices and fuel economy levels for new vehicles. Several commenters on previous regulatory actions and peer reviewers of the CAFE Model encouraged NHTSA to consider the potential impact of fuel efficiency standards on new vehicle prices and sales, the changes to compliance strategies that those shifts

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[642] *See* 87 FR 25856. NHTSA notes that Consumer Reports has seemingly discountiued reporting this statistic in the report accompanying their comment to the proposal.

[643] *See* 87 FR 25856.

[644] *See* EPA Automotive Trends Report, Available at: *https://www.epa.gov/automotive-trends/explore-automotive-trends-data#DetailedData,* (Accessed: April 12, 2024).

[645] *See* Cox Automotive, ''New-vehicle inventory surpasses 2.5 million units, 71 days' supply'', December 14, 2023, available at: *https://www.coxautoinc.com/market-insights/new-vehicle-inventory-november-2023/,* (Accessed: April 12, 2024).

[646] CEA, Docket No. NHTSA–2023–0022–61918, at 18.

could necessitate, and the accompanying impact on vehicle retirement rates. In particular, the continued growth of the utility vehicle segment causes changes within some manufacturers' fleets as sales volumes shift from one region of the footprint curve to another, or as mass is added to increase the ride height of a vehicle originally designed on a sedan platform to create a crossover utility vehicle with the same footprint as the sedan on which it is based.

The analysis accompanying this final rule, like the 2020 and 2022 rulemakings, dynamically simulates changes in the vehicle fleet's size, composition, and usage as manufacturers and consumers respond to regulatory alternatives, fuel prices, and macroeconomic conditions. The analysis of fleet composition is comprised of two forces: how sales of new vehicles and their integration into the existing fleet change in response to each regulatory alternative, and the influence of economic and regulatory factors on retirement of used vehicles from the fleet (or scrappage). Below are brief descriptions of how the agency models sales and scrappage; for full explanations, readers should refer to Chapter 4.2 of the TSD.

A number of commenters argued that future demand for BEVs is likely to be weaker than assumed by the agency and that the agency's approach to forecasting sales should account for the possibility of BEV adoption causing the total number of new vehicles sales to drop. These commenters theorize that buyers' skepticism towards new technology, the limited driving range of most current BEVs, lack of charging infrastructure, uncertainty over battery life and resale value, and generally higher purchase prices will combine to hamper BEV sales. Commenters similarly argued that even if consumers do purchase BEVs, they will drive fewer miles because of limited charging infrastructure.

Within the CAFE Model's logic, there is an implicit assumption that new vehicle models within the same vehicle class (*e.g.,* passenger cars v. light trucks) are close substitutes for one another, including vehicles with differing powertrains.[647] NHTSA recognizes that different vehicle attributes may change a vehicle's utility and NHTSA has implemented several safeguards to prevent the CAFE Model from adopting technologies for fuel economy that could adversely affect the utility of vehicles, such as maintaining performance neutrality, including phase-in caps, and using engineering judgment in defining technology pathways. The agency further considers that even with these safeguards in place, there is a potential that vehicles could have been improved in ways that would have further increased consumer utility in the absence of standards.

This is not the first time the agency has received comments suggesting that other vehicle attributes beyond price and fuel economy affect vehicle sales and usage. Some commenters to past rules have suggested that a more detailed representation of the new vehicle market would enable the agency to incorporate the effect of additional vehicle attributes on buyers' choices among competing models, reflect consumers' differing preferences for specific vehicle attributes, and provide the capability to simulate responses such as strategic pricing strategies by manufacturers intended to alter the mix of models they sell and enable them to comply with new CAFE standards. The agency has previously invested considerable resources in developing such a discrete choice model of the new automobile market, although those investments have not yet produced a satisfactory and operational model.

The agency's experience partly reflects the fact that these models are highly sensitive to their data inputs and estimation procedures, and even versions that fit well when calibrated to data from a single period—usually a cross-section of vehicles and shoppers or actual buyers—often produce unreliable forecasts for future periods, which the agency's regulatory analyses invariably require. This occurs because they are often unresponsive to relevant shifts in economic conditions or consumer preferences, and also because it is difficult to incorporate factors such as the introduction of new model offerings—particularly those utilizing advances in technology or vehicle design—or shifts in manufacturers' pricing strategies into their representations of choices and forecasts of future sales or market shares. For these reasons, most vehicle choice models have been better suited for analysis of the determinants of historical variation in sales patterns than to forecasting future sales volumes and market shares of particular categories.

Commenters' predictions of weak BEV demand demonstrate exactly how formidable these challenges can be. The information commenters used to arrive at their conclusions is largely informed by characteristics from some of the earliest BEVs introduced into the market. Many of the factors that commenters raised as weaknesses such as range, sparse charging infrastructure, and high prices, have already experienced significant improvements since those early models were released, and the agency anticipates that efforts such as funding for charging stations and tax credits from the BIL and the IRA will only serve to further enhance these attributes.

Some commenters also offered subjective opinions of BEVs that they felt the agency should consider in their analysis which NHTSA finds too subjective to include in its primary regulatory analysis. For example, one commenter suggested that consumers will reject BEVs because they are "less fun" to drive than "freedom machines."[648] However, some consumers find the driving experience of BEVs preferrable to ICE vehicles because of their quietness, quick response, and ability to be charged from nearly anywhere with a working outlet. Moreover, as a larger and more diverse array of vehicle models become available with BEV powertrains consumers will be more likely to find vehicles in this class that satisfy their desire for other attributes. Under these conditions, NHTSA would expect that consumer acceptance for BEVs will normalize and more closely resemble current consumer demand for other new vehicles.

However, commenters are likely to be correct that some demographic segment of consumers will still have reservations about transitioning to BEVs, especially in the near-term. NHTSA's standards are performance-based standards, and the market can dictate which technologies should be applied to meet the standards. While the agency believes there is a strong chance that the number of BEVs that will be voluntarily adopted are underestimated in the agency's CAFE Model simulations due to how the agency incorporates EPCA's statutory constraints, the CAFE Model simulations project that BEVs will represent only a quarter of the fleet by MY 2031—all of which occurs in the reference baseline. While the agency disagrees with these commenters, if commenters are correct in their assertions that BEV demand will be weak, the CAFE Model simulations show that consumers will continue to

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[647] The CAFE Model does not assign different preferences between technologies, and outside the standard setting restrictions, will apply technology on a cost-effectiveness basis. Similarly, outside of the sales response to changes in regulatory costs, consumers are assumed to be indifferent to specific technology pathways and will demand the same vehicles despite any changes in technological composition.

[648] Heritage Foundation, Docket No. NHTSA–2023–0022–61952, at 6–7.

enjoy a heterogenous marketplace with both BEV and non-BEV options, and those who are strongly averse to purchasing a BEV are represented within the nearly 70 percent of the fleet that remains non-electrified under the reference baseline.

NHTSA also notes that consumer acceptance towards EVs is likely to continue to normalize as a larger and more diverse array of vehicle models become available. The likelihood of weak demand raised by commenters is as likely as the possibility that the agency is understating the demand for BEVs. In FRIA Chapter 9, NHTSA examined sensitivity cases in which it alternately imposed its EPCA standard setting year constraints on BEV adoption in each calendar year of its analysis, and in which it did not force compliance with other ZEV regulatory programs and found positive net benefits from the preferred alternative in each case. For these reasons, NHTSA believes that it is appropriate to continue to assume modeling BEVs and ICE vehicles as substitutes is reasonable.

a. Sales

For the purposes of regulatory evaluation, the relevant metric is the *difference* in the number of new vehicles sold between the baseline and each alternative rather than the absolute number of sales under any alternative. Recognizing this, the agency's analysis of the response of new vehicle sales to requiring higher fuel economy includes three components: a forecast of sales under the baseline alternative (based exclusively on macroeconomic factors), a price elasticity of new vehicle demand that interacts with estimated price increases under each alternative to create differences in sales relative to the No-Action alternative in each year, and a fleet share model that projects differences in the passenger car and light truck market share under each alternative. For a more detailed description of these three components, see Chapter 4.2 of the TSD.

The agency's baseline sales forecast reflects the idea that total new vehicle sales are primarily driven by conditions in the U.S. economy that are outside the influence of the automobile industry. Over time, new vehicle sales have been cyclical—rising when prevailing economic conditions are positive (periods of growth) and falling during periods of economic contraction. While changes to vehicles' designs and prices that occur as consequences of manufacturers' compliance with earlier standards (and with regulations on vehicles' features other than fuel economy) exert some influence on the volume of new vehicle sales, they are far less influential than macroeconomic conditions. Instead, they produce the marginal differences in sales among regulatory alternatives that the agency's sales module is designed to simulate, with increases in new models' prices reducing their sales, although only modestly.

The first component of the sales response model is the nominal forecast, which is based on a small set of macroeconomic inputs that together determine the size of the new vehicle market in each future year under the baseline alternative. This statistically based model is intended only to project a baseline forecast of LDV sales; it does not incorporate the effect of prices on sales and is not intended to be used for analysis of the response to price changes in the new vehicle market. NHTSA's projection oscillates from model year to model year at the beginning of the analysis, before settling to follow a constant trend in the 2030s. This result seems consistent with the continued response to the pandemic and to supply chain challenges. NHTSA's projections of new light-duty vehicle sales during most future years fall between those reported in AEO 2023, and the 2022 final rule which were used as sensitivity cases. NHTSA will continue to monitor changes in macroeconomic conditions and their effects on new vehicle sales, and to update its baseline forecast as appropriate.

NHTSA received several comments suggesting that EV adoption would weaken demand for new vehicles, leading to a decrease in the total amount of vehicles sold.[649] As noted, NHTSA believes that total vehicle sales are largely driven by exogenous macroeconomic conditions. Some commenters also raised the fact that NHTSA does not account for the effects of higher EV prices in its baseline sales forecast. This is consistent with the agency's treatment of other technologies that it projects will be adopted under the No-Action Alternative, either because they prove to be cost-effective or are compelled by other government standards. In addition, we note that the value of tax credits and additional fuel savings are assumed not to affect new vehicle sales because the forecast of sales generated by the CAFE Model for that alternative does not incorporate a response to changes in their effective price.

The baseline HDPUV fleet is modeled differently. NHTSA considered using a statistical model drawn from the LD specification to project new HDPUV sales but reasoned that the mix of HDPUV buyers and vehicles was sufficiently different that an alternative approach was required. Due to a lack of historical and future data on the changing customer base in the HDPUV market (*e.g.,* the composition of commercial and personal users) and uncertainty around vehicle classification at the margin between the LDV and HDPUV categories, NHTSA chose to rely on an exogenous forecast of HDPUV sales from the AEO. To align with the technology used to create the model fleet, NHTSA used compliance data from multiple model years to estimate aggregate sales for MY 2022, and then applied year-over-year growth rates implicit in the AEO forecast to project aggregate sales for subsequent MYs. Since the first year of the analysis, MY 2022, was constructed using compliance data spanning nearly a decade, the aggregate number of sales for the simulated fleet in MY 2022 was lower than the MY 2022 AEO forecast. To align with the AEO projections, the agency adjusted the growth rate in HDPUV sales upward by 2 percent for MYs 2023–2025, and 2.5 percent for MYs 2026–2028. Instead of adjusting the fleet size to match AEO's forecast for MY2022, the agency elected to phase-in the increase in growth rates over a span of years to reflect the likelihood that HDPUV production will continue to face supply constraints resulting from the COVID pandemic in the near future but should return to normal levels sometime later in the decade.

TheXXXifferd component of the sales response model captures how price changes affect the number of vehicles sold; NHTSA estimates the change in sales from its baseline forecast during future years under each regulatory alternative by applying an assumed price elasticity of new vehicle demand to the percent difference in average price between that regulatory alternative and the baseline. This price change does not represent an increase or decrease from the previous year, but rather the percent difference in the average price of new vehicles between the baseline and each regulatory alternative for that year. In the baseline, the average new vehicle price is defined as the observed price in 2022 (the last historical year before the simulation begins) plus the average regulatory cost associated with the No-Action Alternative for each future model year.[650] The central

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[649] Heritage Foundation, Docket No. NHTSA–2023–0022–61952, at 11.

[650] The CAFE Model currently operates as if all costs incurred by the manufacturer as a consequence of meeting regulatory requirements, whether those are the cost of additional technology

analysis in this final rule simulates multiple programs simultaneously (CAFE fuel economy and HDPUV fuel efficiency final standards, EPA's 2021 GHG standards, ZEV, and the California Framework Agreement), and the regulatory cost includes both technology costs and civil penalties paid for non-compliance with CAFE standards in a model year. We also subtract any IRA tax credits that a vehicle may qualify for from those regulatory costs to simulate sales.[651] Because the elasticity assumes no perceived change in the quality of the product, and the vehicles produced under different regulatory scenarios have inherently different operating costs, the price metric must account for this difference. The price to which the elasticity is applied in this analysis represents the residual price difference *between the baseline and each regulatory alternative* after deducting the value of fuel savings over the first 2.5 years of each model year's lifetime.

The price elasticity is also specified as an input, and for the proposal, the agency assumed an elastic response of −0.4—meaning that a five percent increase in the average price of a new vehicle produces a two percent decrease in total sales. NHTSA sought comment on this assumption. Commenters were split over the magnitude of NHTSA's assumed elasticity value. NRDC suggested that more recent studies support a lower magnitude but agreed that NHTSA's choice was reasonable.[652] NADA argued that NHTSA should consider an elasticity of −1 due to the alternatives available to consumers, like repairing used vehicles, XXXifferc transport, and ridesharing services.[653] After reviewing these and other comments, however, NHTSA does not believe that there is a strong empirical case for changing its assumption. As commenters suggestions reveal, estimates of this parameter reported in published literature vary widely, and NHTSA continues to believe that its choice is a reasonable one within this range,[654] but also includes sensitivity cases that explore higher and lower elasticities. Chapter 4.2.1.2 of the TSD further presents the totality of present evidence that NHTSA believes supports its decision.

NADA also asserted that NHTSA did not release the price data used to conduct its sales adjustment. MSRP data, price increase data, and tax credit value data are all available in NHTSA's vehicles report that accompanied both the proposal and final rule. NADA furthermore suggested that NHTSA did not correctly implement its sales adjustment.[655] NADA submitted a similar comment to the agency's 2024–2026 proposal and like there, NHTSA determined that NADA did not correctly determine the change in effective cost or accurately track the No-Action alternative's average effective cost of vehicles to which the regulatory alternative's average effective cost is compared.

Commenters also offered differing suggestions about whether and how NHTSA should incorporate fuel savings into its sales adjustment. NADA suggested that NHTSA should not include fuel savings in the calculation of sales effects since fuel savings do not affect the ability of consumers to obtain financing for new vehicles and argued that financing would act as a barrier to consumers looking to purchase more expensive vehicles that offer greater fuel savings. In support of their argument, NADA cited informal polls conducted by the American Financial Services Association (AFSA) and Consumer Bankers Association showing that approximately 85% of their surveyed members would not extend additional funds to finance more fuel-efficient vehicles.[656] In contrast, NRDC and others argued that the agency's estimate of sales effects was likely to be too large if, as they suggest, consumers value more than 30 months of fuel savings.[657]

NHTSA continues to believe that its approach is reasonable based on its analysis of consumer valuation of fuel savings. As noted in the FRIA Chapter 2.4, there are recent findings in the literature that show a wide range in the estimates of how consumers value fuel savings.

While fuel savings may not influence the terms of a lease or financing offer, the lack of preferential financing for more fuel-efficient vehicles would only prevent consumers for whom the vehicle's price is nearly prohibitive from purchasing the new vehicle in the event of a price increase (*e.g.,* only the marginal consumer would be affected). The lack of preferential financing would not affect consumers' willingness to pay for fuel economy or the fuel savings realized by consumers who do purchase more fuel-efficient vehicles. New vehicle prices have grown significantly from 2020, largely due to supply constraints during and immediately following the COVID–19 pandemic, as well as continued growth in demand for more expensive SUVs and trucks, and manufacturers removing some lower priced model lines from their fleets.[658] The NY Federal Reserve's Survey of Consumer Expectations has found that rejection rates for auto loans did increase in 2023 to around 11 percent of auto loans.[659] However, the share of consumers who reported that they are likely to apply for an auto loan in the next year declined only marginally from 2022. Higher rejection rates are in line with other forms of credit like credit cards, and mortgage refinance applications which also increased during this timeframe as interest rates have also increased significantly since 2022.[660] At the same time, new vehicle sales grew sharply from 2022 to 2023. Higher prices and interest rates do not appear to be driving consumers out of the market altogether, but rather leading consumers to pursue longer term loans, as Experian reported that the average auto loan term had grown to 68 months in 2024.[661] The effect of higher new vehicle prices on access to financing does not appear to be significantly driving consumers out of the market altogether. Interest rates are also cyclical and assuming interest rates continue to remain constant over the next decade is unrealistic. Thus, NHTSA believes that the rising prices that consumers would face as a result of higher compliance costs could still be financed by a large

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applied to vehicles in order to improve fleetwide fuel economy or civil penalties paid when fleets fail to achieve their standard, are ''passed through'' to buyers of new vehicles in the form of price increases.

[651] For additional details about how we model tax credits, see Section II.C.5b above.

[652] Joint NGOs, Docket No. NHTSA–2023–0022–61944, at 71.

[653] NADA, Docket No. NHTSA–2023–0022–58200, at 8.

[654] Jacobsen et al. (2021) report a range of estimates, with a value of approximately −0.4 representing an upper bound of this range. We select this point estimate for the central case and explore alternative values in the sensitivity analysis. Jacobsen, M. et al. 2021. The Effects of New-Vehicle Price Changes on New- and Used-Vehicle Markets and Scrappage. EPA–420–R–21–019. Washington, DC. Available at: *https://cfpub.epa.gov/si/si_public_record_Report.cfm?Lab=OTAQ&dirEntryId=352754.* (Accessed: Feb. 13, 2024).

[655] *Id.*

[656] *Id.* at 8–9.

[657] Joint NGOs, Docket No. NHTSA–2023–0022–61944, at71.

[658] Bartlett, Jeff S., ''Cars Are Expensive. Here's Why and What You Can Do About It.'' Consumer Reports, Sep. 13, 2023, Available at: *https://www.consumerreports.org/cars/buying-a-car/people-spending-more-on-new-cars-but-prices-not-necessarily-rising-a3134608893/* (Accessed: April 17, 2024).

[659] ''Consumers Expect Further Decline in Credit Applications and Rise in Rejection Rates'', Federal Reserve Bank of New York, Press Release, November 20, 2023, Available at: *https://www.newyorkfed.org/newsevents/news/research/2023/20231120,* (Accessed: April 5, 2024).

[660] *Id.*

[661] Horymski, Chris, ''Average Auto Loan Debt Grew 5.2% to $23,792 in 2023'', Experian, Feb. 13, 2024, Available at: *https://www.experian.com/blogs/ask-experian/research/auto-loan-debt-study/,* (Accessed: April 5, 2024).

share of Americans, allowing them to take advantage of fuel savings. As a result, NHTSA has not chosen to model access to financing as a constraint on sales that would be affected incrementally by changes to fuel economy standards. NHTSA believes that consumers are likely to be willing to pay more in financing costs, if the perceived benefits of the vehicle outweigh these costs. Indeed, Consumer Reports noted in its comments, 70 percent of Americans expressed willingness to pay more to lease or purchase a vehicle if its fuel savings outweighed the added cost.

The third and final component of the sales model, which only applies to the light-duty fleet, is the dynamic fleet share module (DFS). For the 2020 and 2022 rulemakings, NHTSA used a DFS model that combines two functions from an earlier version of NEMS to estimate the sales shares of new passenger cars and light trucks based on their average fuel economy, horsepower, and curb weight, current fuel prices, and their prior year's market shares and attributes. The two independently estimated shares are then normalized to ensure that they sum to one. However, as the agency explained in the 2022 final rulemaking, that approach had several drawbacks including the model showing counterintuitive responses to changes in attributes, its exclusion of a price variable, and the observed tendency of the model to overestimate the share of total sales accounted for by passenger automobiles.[662]

For this final rule, NHTSA has revised the inputs used to develop its DFS. The baseline fleet share projection is derived from the agency's own compliance data for the 2022 fleet, and the 2023 AEO projections for subsequent model years. To reconcile differences in the initial 2022 shares, NHTSA projected the fleet share forward using the annual changes from 2022 predicted by AEO and applied these to the agency's own compliance fleet shares for MY 2022.[663] The fleet is distributed across two different body-types: ''cars'' and ''light trucks.'' While there are specific definitions of ''passenger cars'' and ''light trucks'' that determine a vehicle's regulatory class, the distinction used in this phase of the analysis is simpler: all body styles that are commonly considered cars, including sedans, coupes, convertibles, hatchbacks, and station wagons, are defined as ''cars'' for the purpose of determining their fleet share. Everything else—SUVs, smaller SUVs (crossovers), vans, and pickup trucks—are defined as ''light trucks,'' even though some models included in this category may not be treated as such for compliance purposes.

These shares are applied to the total industry sales derived in the first stage of the total sales model to estimate sales volumes of car and light truck body styles. Individual model sales are then determined using the following sequence: (1) individual manufacturer shares of each body style (either car or light truck) are multiplied by total industry sales of that body style, and then (2) each vehicle within a manufacturer's volume of that body-style is assigned the same percentage share of that manufacturer's sales as in model year 2022. This implicitly assumes that consumer preferences for particular styles of vehicles are determined in the aggregate (at the industry level), but that manufacturers' sales shares of those body styles are consistent with their MY 2022 sales. Within a given body style, a manufacturer's sales shares of individual models are also assumed to be constant over time.

This approach also implicitly assumes that manufacturers are currently pricing individual vehicle models within market segments in a way that maximizes their profit. Without more information about each manufacturer's true cost of production, including its fixed and variable components, and its target profit margins for its individual vehicle models, there is no basis to assume that strategic shifts within a manufacturer's portfolio will occur in response to standards. In its comments, IPI noted that this could lead to overestimates of compliance costs, since manufacturers that can more cost-effectively comply with higher standards will be able to capture a larger market share through lower vehicle prices.[664] IPI's assertion may be correct, however NHTSA believes that within its current model there is not a clear way to incorporate such an adjustment, since it would involve evaluating substitution patterns between individual models over a longtime horizon.

Similar to the second component of the sales module, the DFS then applies an elasticity to the change in price between each regulatory alternative and the No-Action Alternative to determine the change in fleet share from its baseline value. NHTSA uses the net regulatory cost differential (costs minus fuel savings) in a logistic model to capture the changes in fleet share between passenger cars and light trucks, with a relative price coefficient of −0.000042. NHTSA selected this methodology and price coefficient based on a review of academic literature.[665] When the total regulatory costs of meeting new standards for passenger automobiles minus the value of the resulting fuel savings exceeds that of light-trucks, the market share of light-trucks will rise relative to passenger automobiles. For example, a $100 net regulatory cost increase in passenger automobiles relative to light trucks would produce a ~.1% shift in market share towards light trucks, assuming the latter initially represent 60% of the fleet.

The approach for this final rule to modeling changes in fleet share addresses several key concerns raised by NHTSA in its prior rulemaking. The model no longer produces counterintuitive effects, and now directly considers the impacts of changes in price. Because the model applies fuel savings in determining changes in relative prices between passenger cars and light trucks, the current approach does not require it to separately consider the utility of fuel economy when determining the respective market shares of passenger automobiles and light trucks. In prior rules, NHTSA has speculated that the rise in light-truck market share may be attributable to the increased utility that light-trucks provide their operators, and as the fuel economy difference between those two categories diminished, light-trucks have become an even more attractive option. As explained in a docket memo accompanying this final rule, NHTSA has been unable to create a comprehensive model that includes vehicle prices, fuel economy, and other attributes that produces appropriate responses to changes in each of these factors, so the agency is considering applying an elasticity to the changes in fuel economy directly to capture this change in utility. Consumer Reports argued that NHTSA's dynamic fleet share model was too uncertain for use in the CAFE Model.[666] While fleet share's response to changes in the standards is an uncertain factor to project, NHTSA based its model on peer reviewed results and a well-grounded

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[662] 84 FR 25861 (May 2, 2022).

[663] For example if AEO passenger car share grows from 40 percent in one year to 50 percent in the next (25 percent growth), and our compliance passenger car share in that year is 44 percent then the predicted share in the next year would be 55 percent (11 points or 25 percent higher).

[664] IPI, Docket No. NHTSA–2023–0022–60485, at 21–22.

[665] The agency describes this literature review and the calibrated logit model in more detail in the accompanying docket memo ''Calibrated Estimates for Projecting Light-Duty Fleet Share in the CAFE Model''.

[666] Consumer Reports, Docket No. NHTSA–2023–0022–61098, at 18.

methodology described in a docket memo ''Calibrated Estimates for Projecting Light-Duty Fleet Share in the CAFE Model.'' Finally, some commenters expressed confusion about NHTSA's approach to modeling fleet share. NHTSA explains its approach using a combination of a fixed fleet share forecast for the No-Action alternative, and a dynamic fleet share model to adjust fleet share projections in the regulatory alternatives in TSD Chapter 4.2.

b. Scrappage

New and used vehicles can substitute for each other within broad limits, and when the prices of substitutes for a good increase or decrease, demand for that good responds by rising or falling, causing its equilibrium price and quantity supplied to also rise or fall. Thus, increasing the quality-adjusted price of new vehicles will increase demand for used vehicles, and by doing so raise their equilibrium market value or price and the number that are kept in service. Because used vehicles are not being produced, their supply can only be increased by keeping more of those that would otherwise be retired in use longer, which corresponds to a reduction in their scrappage or retirement rates.

When new vehicles become more expensive, demand for used vehicles increases, but meeting the increase in demand requires progressively more costly maintenance and repairs to keep more of them in working condition, in turn causing them to become more expensive. Because used vehicles are more valuable in such circumstances, they are scrapped at a lower rate, and just as rising new vehicle prices push some prospective buyers into the used vehicle market, rising prices for used vehicles force some prospective buyers to acquire even older vehicles or models with fewer desired attributes. The effect of fuel economy standards on scrappage is partially dependent on how consumers value future fuel savings and our assumption that consumers value only the first 30 months of fuel savings when making a purchasing decision.

Many competing factors influence the decision to scrap a vehicle, including the cost to maintain and operate it, the household's demand for VMT, the cost of alternative means of transportation, and the value that can be attained through reselling or scrapping the vehicle for parts. In theory, a car owner will decide to scrap a vehicle when the value of the vehicle minus the cost to maintain or repair the vehicle is less than its value as scrap material; in other words, when the owner realizes more value from scrapping the vehicle than from continuing to drive it or from selling it. Typically, the owner that scraps the vehicle is not the original vehicle owner.

While scrappage decisions are made at the household level, NHTSA is unaware of sufficiently detailed household data to sufficiently capture scrappage at that level. Instead, NHTSA uses aggregate data measures that capture broader market trends. Additionally, the aggregate results are consistent with the rest of the CAFE Model, as the model does not attempt to model how manufacturers will price new vehicles; the model instead assumes that all regulatory costs to make a particular vehicle compliant are passed onto the purchaser who buys the vehicle.

The dominant source of vehicles' overall scrappage rates is ''engineering scrappage,'' which is largely determined by the age of a vehicle and the durability of the specific model year or vintage it represents. NHTSA uses proprietary vehicle registration data from I/Polk to estimate vehicle age and durability. Other factors affecting owners' decisions to retire used vehicles or retain them in service include fuel economy and new vehicle prices; for historical data on new vehicle transaction prices, NHTSA uses National Automobile Dealers Association (NADA) Data.[667] The data consist of the average transaction price of all LDVs; since the transaction prices are not broken-down by body style, the model may miss unique trends within a particular vehicle body style. The transaction prices are the amount consumers paid for new vehicles and exclude any trade-in value credited towards the purchase. This may be particularly relevant for pickup trucks, which have experienced considerable changes in average price as luxury and high-end options entered the market over the past decade. Future versions of the agency's scrappage model may consider incorporating price series that consider the price trends for cars, SUVs and vans, and pickups separately. The final source of vehicle scrappage is from cyclical effects, which the model captures using forecasts of GDP and fuel prices.

Vehicle scrappage follows a roughly logistic function with age—that is, when a vintage is young, few vehicles in the cohort are scrapped; as they age, more and more of the cohort are retired each year and the annual rate at which vehicles are scrapped reaches a peak. Scrappage then declines as vehicles enter their later years as fewer and fewer of the cohort remains on the road. The analysis uses a logistic function to capture this trend of vehicle scrappage with age. The data show that the durability of successive MYs generally increases over time, or put another way, historically newer vehicles last longer than older vintages. However, this trend is not constant across all vehicle ages—the instantaneous scrappage rate of vehicles is generally lower for more recent vintages up to a certain age, but must increase thereafter so that the final share of vehicles remaining converges to a similar share remaining for historically observed vintages.[668] NHTSA's model uses fixed effects to capture potential changes in durability across MYs, and to ensure that vehicles approaching the end of their life are scrapped in the analysis, NHTSA applies a decay function to vehicles after they reach age 30. The macroeconomic conditions variables discussed above are included in the logistic model to capture cyclical effects. Finally, the change in new vehicle prices projected in the model (technology costs minus 30 months of fuel savings and any tax credits passed through to the consumer) is included, and changes in this variable are the source of differing scrappage rates among regulatory alternatives.

For this final rule, NHTSA modeled the retirement of HDPUVs similarly to pick-up trucks. The amount of data for HDPUVs is significantly smaller than for the LD fleet and drawing meaningful conclusions from the small sample size is difficult. Furthermore, the two regulatory classes share similar vehicle characteristics and are likely used in similar fashions, so NHTSA believes that these vehicles will follow similar scrappage schedules. Commercial HDPUVs may endure harsher conditions during their useful life such as more miles in tough operating conditions, which may also affect their retirement schedules. We believe that many light-trucks likely endure the same rigor and are represented in the light-truck segment of the analysis; however, NHTSA recognizes that the intensity or proportionality of heavy use in the HDPUV fleet may exceed that of smaller light trucks.

In addition to the variables included in the scrappage model, NHTSA considered several other variables that

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[667] The data can be obtained from NADA. For reference, the data for MY 2020 may be found at *https://www.nada.org/nadadata/*.

[668] Examples of why durability may have changed are new automakers entering the market or general changes to manufacturing practices like switching some models from a car chassis to a truck chassis.

likely either directly or indirectly influence scrappage in the real world, including maintenance and repair costs, the value of scrapped metal, vehicle characteristics, the quantity of new vehicles purchased, higher interest rates, and unemployment. These variables were excluded from the model either because of difficulties in obtaining data to measure them accurately or other modeling constraints. Their exclusion from the model is not intended to diminish their importance, but rather highlights the practical constraints of modeling intricate decisions like scrappage.

NHTSA sought comment on its scrappage model, as well as on differences between scrappage for light trucks and HDPUVs. IPI suggested that NHTSA replace its reduced form model for scrappage with a structural model, or that it should incorporate the price of used vehicles and other omitted variables in its model to predict scrappage and change its estimation strategy to avoid threats to identification from endogeneity.[669] NHTSA sees merit in the suggestion of a structural model for scrappage but believes it should be implemented as part of a larger change to the CAFE Model in a future rulemaking, since it would also require NHTSA to incorporate a more complex model of the used vehicle market. AFPM commented that increases in the new vehicle prices of ZEVs will also lead to increases in the prices of new ICE vehicles through cross subsidization.[670] NHTSA notes that its scrappage model determines scrappage rates using the average price of new vehicles in each class. Thus, the manufacturers' pricing strategies assumed in the CAFE Model will not affect predicted scrappage rates, since this would only occur where manufacturers raise prices by more or less than the costs they incur to improve the fuel economy of individual models.

MEMA disagreed with NHTSA's approach of modeling HDPUV and light truck scrappage rates using the same function because of differences between fleetwide average use and the average use of the typical vehicle.[671] MEMA noted that one manufacturer had told them that about one-quarter of its fleet remained active for more than 200 percent of the average vehicle's useful life. The maximum age NHTSA assumes for LDVs (40 years) is more than twice their average or ''expected'' lifetime (about 15 years), so this experience does not appear to be unusual. Indeed, in NHTSA's No-Action Alternative case, around 21 percent of HDPUVs produced in model years 2030–2035 were still operating 30 years after entering the fleet. NHTSA thus continues to believe that it is properly estimating scrappage rates at the fleet level and using as much available data as possible to estimate its scrappage rates. For additional details on how NHTSA modeled scrappage, see Chapter 4.2.2 of the TSD.

3. Changes in Vehicle Miles Traveled (VMT)

In the CAFE Model, VMT is projected from average use of vehicles with different ages, the total number in use, and the composition of the fleet by age, which itself depends on new vehicle sales during each earlier year and vehicle retirement decisions. These three components—average vehicle usage, new vehicle sales, and older vehicle scrappage—jointly determine total VMT projections for each alternative. VMT directly influences many of the various effects of fuel economy standards that decision-makers consider in determining what levels of standards to set. For example, the value of fuel savings is a function of a vehicle's fuel efficiency, the number of miles it is driven, and fuel price. Similarly, factors like criteria pollutant emissions, congestion, and fatalities are direct functions of VMT. For a more detailed description of how NHTSA models VMT, see Chapter 4.3 of the TSD.

NHTSA's perspective is that the total demand for VMT should not vary excessively across alternatives, because basic travel needs for a typical household are unlikely to be influenced by the stringency of the standards, so the daily need the services of vehicles to transport household members will remain the same. That said, it is reasonable to assume that fleets with differing age distributions and inherent cost of operation will have slightly different annual VMT (even without considering VMT associated with rebound miles). Because of the structure of the CAFE Model, the combined effect of the sales and scrappage responses can produce small differences in total VMT across the range of regulatory alternatives if steps are not taken to constrain VMT. Because VMT is related to many of the costs and benefits of the program, even small differences in VMT among alternatives can have meaningful impacts on their incremental net benefits. Furthermore, since decisions about alternative stringencies look at the incremental costs and benefits across alternatives, it is more important that the analysis capture the variation of VMT across alternatives—mainly how vehicles are distributed across vehicles and how many rebound miles may occur in any given alternative—than to accurately project total VMT for any single scenario.

To ensure that travel demand remains consistent across the different regulatory scenarios for the LD fleet, the agency's analysis relies on a model of aggregate light-duty VMT developed by the Federal Highway Administration (FHWA) to produce that agency's official VMT projections. The annual forecasts of total VMT generated by this model when used in conjunction with the macroeconomic inputs described previously model are used to constrain the forecasts of annual VMT generated internally by the CAFE model to be identical among the regulatory alternatives during each year in the analysis period.

NHTSA considered removing the constraint on VMT for the final rule after seeking comment from the public. IPI supported allowing VMT to vary with fleet size, arguing that if fleet size decreases some travelers would likely choose to use alternative forms of transportation like car-sharing, or mass transit rather than relying on older vehicles.[672] Ultimately NHTSA did not choose to make this change in the absence of a tractable model for how this VMT would be redistributed across alternative forms of transportation (including additional miles driven by the legacy fleet), and the various costs and benefits this change would produce. NHTSA will continue to explore methods for modeling this kind of reallocation for future rulemakings, including estimating the cross price elasticities of demand for these alternative forms of travel as IPI recommended.

Since vehicles of different ages and body styles have different costs to own and operate but also provide different benefits, to account properly for the average value of consumer and societal costs and benefits associated with vehicle usage under various alternatives, it is necessary to partition miles by age and body type. NHTSA created ''mileage accumulation schedules'' usiIIHS-Polk odometer data to construct mileage accumulation schedules as an initial estimate of how much a vehicle expected to drive at each age throughout its life.[673] NHTSA

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[669] IPI, Docket No. NHTSA–2023–0022–60485, at 26–27.

[670] AFPM, Docket No. NHTSA–2023–0022–61911, at 78.

[671] MEMA, Docket No. NHTSA–2023–0022–59204, at 8.

[672] IPI, Docket No. NHTSA–2023–0022–60485, at 24.

[673] The mileage accumulations schedules are constructed with content supplied by IHS Markit;

uses simulated new vehicle sales, annual rates of retirement for used vehicles, and the mileage accumulation schedules to distribute VMT across the age distribution of registered vehicles in each calendar year to preserve the non-rebound VMT constraint.

FHWA does not produce an annual VMT forecast for HDPUVs. Without an annual forecast, NHTSA is unable to constrain VMT for HDPUVs as it does for the LD fleet. Instead, an estimate of total VMT for HDPUVs is developed from the estimates of annual use for vehicles of each age (the ''mileage accumulation'' schedules) and estimates of the number of HDPUVs of each model year and age that remain in use during each future calendar year. For the reasons described previously, we believe that this method produces reasonable estimates of the differences in total VMT and its distribution among vehicles of different ages that is implied by changes in fleet composition and size between the reference baseline and each regulatory alternative.

The fuel economy rebound effect—a specific example of the well-documented energy efficiency rebound effect for energy-consuming capital goods—refers to motorists who choose to increase vehicle use (as measured by VMT) when their fuel economy is improved and, as a result, the cost per mile (CPM) of driving declines. Establishing more stringent standards than the reference baseline level will lead to comparatively higher fuel economy for new cars and light trucks, and increase fuel efficiency for HDPUVs, thus decreasing the cost of fuel consumed by driving each mile and increasing the amount of travel in new vehicles. NHTSA recognizes that the value selected for the rebound effect influences overall costs and benefits associated with the regulatory alternatives under consideration as well as the estimates of lives saved under various regulatory alternatives, and that the rebound estimate, along with fuel prices, technology costs, and other analytical inputs, is part of the body of information that agency decision-makers have considered in determining the appropriate levels of the standards in this final rule. We also note that larger values for the rebound effect diminishes the economic and environmental benefits associated with increased fuel efficiency.

NHTSA conducted a review of the literature related to the fuel economy rebound effect, which is extensive and covers multiple decades and geographic regions.[674] The totality of evidence, without categorically excluding studies that fail to meet certain criteria and evaluating individual studies based on their particular strengths, suggests that a plausible range for the rebound effect is 10–50 percent. This range implies that, for example, a 10 percent reduction in vehicles' fuel CPM would lead to an increase of 1–5 percent in the number of miles they are driven annually. The central tendency of this range appears to be at or slightly above its midpoint, which is 30 percent. Considering only those studies that NHTSA believes are derived from extremely robust and reliable data, employ identification strategies that are likely to prove effective at isolating the rebound effect, and apply rigorous estimation methods, suggests a range of approximately 10–45 percent, with most of the estimates falling in the 15–30 percent range.

However, published estimates of the rebound effect vary widely, as do the data and methodologies that underpin them. A strong case can also be made to support lower values. Both economic theory and empirical evidence suggest that the rebound effect has been declining over time due to factors such as increasing income (which raises the value of travelers' time), progressive smaller reductions in fuel costs in response to continuing increases in fuel economy, and slower growth in car ownership and the number of license holders. Lower estimates of the rebound effect estimates are associated with recently published studies that rely on U.S. data, measure vehicle use using actual odometer readings, control for the potential endogeneity of fuel economy, and—critically—estimate the response of vehicle use to variation in fuel economy itself rather than to fuel cost per distance driven or fuel prices. According greater weight to these studies suggests that the rebound effect is more likely to be in the 5–15 percent range. For a more complete discussion of the rebound literature, see TSD Chapter 4.3.5.

NHTSA selected a rebound effect of 10% for its analysis of both LD and HDPUV fleets because it was well-supported by the totality of the evidence.[675] It is rarely possible to identify whether estimates of the rebound effect in academic literature apply specifically to household vehicles, LDVs, or another category, and different nations classify trucks included in NHTSA's HDPUV category in varying ways, so NHTSA has assumed the same value for LDVs and HDPUVs.

We also examine the sensitivity of estimated impacts to values of the rebound ranging from 5 percent to 15 percent to account for the uncertainty surrounding its exact value. NHTSA sought comment on the above discussion, and whether to consider a different value for the rebound effect for the final rule analysis for either the LD or HDPUV analyses. IPI agreed with NHTSA's choice, arguing that it was well supported in the literature.[676]

AFPM disagreed with NHTSA's approach to modeling mileage for BEVs, suggesting that some studies find that these vehicles are driven less than ICE vehicles, and so NHTSA's assumption that any decrease in operating costs that these vehicles convey to their owner will not cause them to ultimately be used more overall.[677] In response, NHTSA examined the VMT accumulation for BEVs relative to ICE counterparts. Preliminary results showed lower VMT for these vehicles than ICE vehicles, but the agency notes that given the lack of more recent data, this result is driven mostly by early iterations of mainstream BEVs which had shorter ranges, longer recharging times, and significantly fewer charging stations. NHTSA believes that these factors likely played a bigger role in determining their usage than consumers' innate preferences for EVs vs. ICE vehicles. and concluded that there were significant limitations that prevented the agency from being able to project forward these differences with confidence. First, historically, these vehicles have been limited to only a small subset of manufacturers, and segments of the overall market. According to NHTSA's analysis and publicly announced production plans, this is projected to change in the years prior to NHTSA's standard setting years considered in this rulemaking.[678] This will make the owners of these vehicles, and their use patterns more representative of drivers as a whole. Second, the quality of the vehicle charging network is projected to improve significantly as programs like NEVI funded by the Bipartisan

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[674] See TSD Chapter 4.3.

[675] The HDPUV and light trucks experience similar usage patterns (hence why we estimate technology effectiveness on 2-cycle tests similar to CAFE) and without a strong empirical evidence to suggest an alternative estimate, decided it was appropriate to use the same estimate.

[676] IPI, Docket No. NHTSA–2023–0022–60485, at 26–28.

[677] AFPM, Docket No. NHTSA–2023–0022–61911, at 52, 76.

[678] Miller, Caleb, ''Future Electric Vehicles: The EVs You'll Soon Be Able to Buy'', *Car and Driver,* Available at: *https://www.caranddriver.com/news/g29994375/future-electric-cars-trucks/*. (Accessed: April 5, 2024).

Infrastructure Law continue to be implemented. This will enable drivers in areas without at-home charging to make more use of these vehicles and will enable all drivers to travel longer distances in BEVs. Based on these factors, NHTSA believes that projecting BEV use into the future based on differences in their usage in recent years would introduce more error into the model than maintaining its current assumption. NHTSA is continuing to study this issue and will monitor the evidence to determine if changes need to be made in future rulemakings.

In order to calculate total VMT after allowing for the rebound effect, the CAFE Model applies the price elasticity of VMT (taken from the FHWA forecasting model) to the change in fuel cost per mile resulting from higher fuel economy and uses the result to adjust the initial estimate of each model's annual use accordingly. The CAFE model applies this adjustment after the reallocation step described previously, since that adjustment is intended to ensure that total VMT is identical among alternatives *before* considering the contribution of increased driving due to the rebound effect. Its contribution differs among regulatory alternatives because those requiring higher fuel economy lead to larger reductions in the fuel cost of driving each mile, and thus to larger increases in vehicle use.

The approach used in NHTSA's CAFE model is thus a combination of ''top-down'' (relying on the FHWA forecasting model to determine total LD VMT in a given calendar year) and ''bottom-up'' (where the composition and utilization of the on-road fleet determines a base level of VMT in a calendar year, which is constrained to match the FHWA model) forecasting. See Chapter 4.3 of the TSD for a complete accounting of how NHTSA models VMT.

4. Changes to Fuel Consumption

NHTSA uses the fuel economy and age and body-style VMT estimates to determine changes in fuel consumption. NHTSA divides the expected vehicle use by the anticipated mpg to calculate the gallons consumed by each simulated vehicle, and when aggregated, the total fuel consumed in each alternative.

F. Simulating Emissions Impacts of Regulatory Alternatives

This final rule encourages manufacturers of light-duty vehicles and HDPUVs to employ various fuel-saving technologies to improve the fuel efficiency of some or all the models they produce, and in addition to reducing drivers' outlays for fuel, the resulting reductions in their fuel consumption will produce additional benefits. These benefits include reduced vehicle emissions during their operation, as well as lower ''upstream'' emissions from extracting petroleum, transporting, and refining it to produce transportation fuels, and finally transporting, storing, and distributing fuel. This section provides a detailed discussion of how the agency estimates the resulting reductions in emissions, particularly for the main standard-setting options, including the development and evolution of parameters to estimate emissions of criteria pollutants, GHGs, and air toxics, and the potential improvements in human health from reducing them.

The rule implements an ''emissions inventory'' methodology for estimating its emissions impacts. Vehicle emissions inventories are often described as three-legged stools, comprised of vehicle activity (*i.e.,* miles traveled, hours operated, or gallons of fuel burned), population (or number of vehicles), and emission factors.[679] An emission factor is a representative rate that attempts to relate the quantity of a pollutant released to the atmosphere per unit of activity. For this rulemaking, like past rules, activity levels (both miles traveled and fuel consumption) are generated by the CAFE Model, while emission factors have been adapted from models developed and maintained by other Federal agencies.

The following section briefly discusses the methodology the CAFE Model uses to track vehicle activity and populations, and how we generate the emission factors that relate vehicle activity to emissions of criteria pollutants, GHGs, and air toxics. This section also details how we model the effects of these emissions on human health, especially in regard to criteria pollutants known to cause poor air quality. Further description of how the health impacts of criteria pollutant emissions can vary and how these emission damages have been monetized and incorporated into the rule can be found in Preamble Section III.G, Chapter 6.2.2 of the TSD, and the Final EIS accompanying this analysis.

For transportation applications, emissions are generated at several stages between the initial point of energy feedstock extraction and delivering fuel to vehicles' fuel tanks or energy storage systems; in lifecycle analysis, these are often referred to ''upstream'' or ''well-to-tank'' emissions. In contrast, ''downstream'' or ''tank-to-wheel'' emissions are primarily comprised of those emitted by vehicles' exhaust systems, but also include other emissions generated during vehicle refueling, use, and inactivity (called 'soaking'), including hydrofluorocarbons leaked from vehicles' air conditioning (AC) systems. They also include particulate matter (PM) released into the atmosphere by brake and tire wear (BTW) as well as evaporation of volatile organic compounds (VOCs) from fuel pumps and vehicles' fuel storage systems during refueling and when parked. Cumulative emissions occurring throughout the fuel supply and use cycle are often called ''well-to-wheel'' emissions in lifecycle analysis.

The CAFE Model tracks vehicle populations and activity levels to produce estimates of the effects of different levels of CAFE standards on emissions and their consequences for human health and the global climate. Tracking vehicle populations begins with the reference baseline or analysis fleet, and estimates of each vehicle's fuel type (*e.g.,* gasoline, diesel, electricity), fuel economy, and number of units sold in the U.S. As fuel economy-improving technology is added to vehicles in the reference baseline fleet in MYs subject to proposed new standards, the CAFE Model estimates annual rates at which new vehicles are purchased, driven,[680] and subsequently scrapped. The model uses estimates of vehicles remaining in service in each year and the amount those vehicles are driven (*i.e.,* activity levels) to calculate the quantities of each type of fuel or energy that vehicles in the fleet consume in each year, including gasoline, diesel, and electricity. The quantities of travel and fuel consumption estimated for the cross section of MYs comprising each CYs vehicle fleet represents the

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[679] There seems to be misalignment in the scientific community as to the use of the term ''emission factor'' and ''emissions factor'' to refer to a singular emission factor, and the use of the term ''emission factors'' and ''emissions factors'' to refer to multiple emission factors; we endeavor to remain consistent in this section and implore the community to come to consensus on this important issue.

[680] The procedures the CAFE Model uses to estimate annual VMT for individual car and light truck models produced during each model year over their lifetimes and to combine these into estimates of annual fleet-wide travel during each future CY, together with the sources of its estimates of their survival rates and average use at each age, are described in detail in TSD Chapters 4.2 and 4.3. The data and procedures the CAFE Model employs to convert these estimates of VMT to fuel and energy consumption by individual model, and to aggregate the results to calculate total consumption and energy content of each fuel type during future CYs, are also described in detail in that section.

''activity levels'' the CAFE model uses to calculate emissions. The model does so by multiplying each activity level by the relevant emission factor and summing the results of those calculations.

Emission factors measure the mass of each greenhouse gas or criteria air pollutant emitted per unit of activity, which can be a vehicle-mile of travel, gallon of fuel consumed, or unit of fuel energy content. We generate emission factors for the following regulated criteria pollutants and GHGs: carbon monoxide (CO), VOCs, nitrogen oxides (NO_X), sulfur oxides (SO_X), particulate matter with a diameter of 2.5-micron (µm) or less ($PM_{2.5}$); CO_2, methane (CH_4), and nitrous oxide (N_2O).[681] In this rulemaking, upstream emission factors are based on the volume of each type of fuel supplied, while downstream emission factors are expressed on a distance-traveled (VMT) basis. Simply stated, the rulemaking's upstream emission inventory is the product of the per-gallon emission factor and the corresponding number of gallons of gasoline or diesel, or amount of electricity,[682] produced and distributed. Similarly, the downstream emission inventory is the product of the per-mile emission factor and the appropriate miles traveled estimate. The only exceptions are that tailpipe emissions of SO_X and CO_2 are also calculated on a per-gallon emission basis using appropriate emission factors in the CAFE Model. EVs do not produce combustion-related (tailpipe) emissions,[683] however, EV upstream electricity emissions are also accounted for in the CAFE Model inputs. Upstream and downstream emission factors and subsequent inventories were developed independently from separate data sources, as discussed in detail below.

The analysis for the NPRM used upstream emission factors derived from GREET 2022, which is a lifecycle emissions model developed by the U.S. DOE's Argonne National Laboratory (Argonne). GREET 2022 projected a national mix of fuel sources used for electricity generation (often simply called the grid mix) for transportation from the latest AEO data available, in that case from 2022. For the final rule, we updated upstream petroleum (gasoline and diesel) and electricity emission factors using R&D GREET 2023.[684] Petroleum emission factors are based on R&D GREET 2023 assumptions derived from AEO 2023, while electricity emission factors are derived from an electricity forecast from the National Renewable Energy Laboratory's 2022 Standard Scenarios report.[685] A detailed description of how we used R&D GREET 2023 to generate upstream emission factors appears in Chapter 5 of the TSD, as well as in the Electricity Grid Forecasts docket memo accompanying this rule.

Other grid mixes with higher penetrations of renewables are presented as sensitivity cases in the FRIA and provide some context about how the results of our analysis would differ using a grid mix with a higher penetration of renewable energy sources. We sought comment on these sensitivity cases and which national grid mix forecast best represents the latest market conditions and policies, such as the Inflation Reduction Act. We also sought comments on other forecasts to consider, including EPA's Integrated Planning Model for the post-IRA 2022 reference case for the final rulemaking,[686] and the methodology used to generate alternate forecasts. We received no comments on our grid mix assumptions; however, to be consistent with DOE's projections in their Petroleum Equivalency Factor (PEF) final rule, we chose to use the 2022 Standard Scenarios report projections.[687]

As in past CAFE analyses, we used GREET to derive emission factors for the following four upstream emission processes for gasoline, E85, and diesel: (1) petroleum extraction, (2) petroleum transportation and storage, (3) petroleum refining, and (4) fuel transportation, storage, and distribution (TS&D)). We calculated average emission factors for each fuel and upstream process during five-year intervals over the period from 2022 through 2050. We considered feedstocks including conventional crude oil, oil sands, and shale oils in the gasoline and diesel emission factor calculations and follow assumptions consistent with the GREET Model for ethanol blending.

In the proposal, NHTSA assumed that any reduction in fuel consumption within the United States would lead to an equal increase in gasoline exports. As a consequence, we projected that domestic fuel production and the upstream emissions it generates would not change, although we did acknowledge that emissions from feedstock extraction and fuel production outside the U.S. were likely to be affected. NHTSA also noted that this assumption was strong and that it was considering how to project changes in domestic fuel production that were likely to result from changes in CAFE and fuel efficiency standards over the long run. NHTSA sought comments on how it should model the response of domestic fuel production to changes in fuel consumption. AFPM commented that the scale of reductions in domestic fuel consumption caused by the proposed standards was likely to cause changes in domestic fuel production, and that NHTSA should consider the rule's impact on biofuel production.[688]

NHTSA re-analyzed projections of domestic fuel production from McKinsey & Company (2023),[689] S&P Global (2023),[690] and the 2023 AEO, and concluded that there is a wide range of estimates about how domestic refining is likely to change over the coming decades, even without considering the potential effects of higher standards. Instead of relying on a single set of projections, NHTSA developed a simplified parameterized economic model for estimating the response of domestic fuel production to changes in U.S. fuel consumption. Using this model, for the final rule NHTSA estimates that 20 percent of the reduction in fuel consumption will be translated into reductions in domestic fuel production. See Chapters 5 and 6.2.4 of the TSD for a more detailed discussion of this process.

We estimated non-CO_2 downstream emission factors for gasoline, E85,

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[681] There is also HFC leakage from air conditioner systems, but these emissions are not captured in our analysis.

[682] The CAFE Model utilizes a single upstream electricity emission factor for each pollutant for transportation use and does not differentiate by process, based on GREET emission factors for electricity as a transportation fuel.

[683] BEVs do not produce any combustion-based emissions while PHEVs only produce combustion-based emissions during use of conventional fuels. Utilization factors typically define how much real-world operation occurs while using electricity versus conventional fuels.

[684] ANL. 2023. The Greenhouse Gases, Regulated Emissions and Energy Use in Transportation (GREET) Model. Argonne National Laboratory. Last revised: December 2023. Available at: *http://greet.es.anl.gov/*. (Accessed: January 25, 2022).

[685] Gagnon, P., M. Brown, D. Steinberg, P. Brown, S. Awara, V. Carag, S. Cohen, W. Cole, J. Ho, S. Inskeep, N. Lee, T. Mai, M. Mowers, C. Murphy, and B. Sergi. 2022. 2022 Standard Scenarios Report: A U.S. Electricity Sector Outlook. Revised March 2023. National Renewable Energy Laboratory. NREL/TP–6A40–84327. Available at: *https://www.nrel.gov/docs/fy23osti/84327.pdf* (Accessed: February 29, 2024).

[686] See EPA. 2023. Post-IRA 2022 Reference Case. Available at: *https://www.epa.gov/power-sector-modeling/post-ira-2022-reference-case.* (Accessed: Feb. 27, 2024).

[687] 89 FR 22041 (March 29, 2024).

[688] AFPM, Docket No. NHTSA–2023–0022–61911, at 12–14.

[689] Ding, Cherry, et. al, Refining in the energy transition through 2040, McKinsey & Company, October, 2022.

[690] Smith, Rob, ''Through the looking glass: Fuel retailing in an era of declining US gasoline demand'' S&P Global, Commodity Insights, September 27, 2023.

diesel, and CNG[691] using EPA's Motor Vehicle Emission Simulator (MOVES4) model, a regulatory highway emissions inventory model developed by that agency's National Vehicle and Fuel Emissions Laboratory.[692] We generated downstream CO_2 emission factors based on the carbon content (*i.e.,* the fraction of each fuel type's mass that is carbon) and mass density per unit of each specific type of fuel, under the assumption that each fuel's entire carbon content is converted to CO_2 emissions during combustion. The CAFE Model calculates CO_2 vehicle-based emissions associated with vehicle operation of the surviving on-road fleet by multiplying the number of gallons of each specific fuel consumed by the CO_2 emission factor for that type of fuel. More specifically, the number of gallons of a particular fuel is multiplied by the carbon content and the mass density per unit of that fuel type, and then the ratio of CO_2 emissions generated per unit of carbon consumed during the combustion process is applied.[693] TSD Chapter 5.3 contains additional detail about how we generated the downstream emission factors used in this analysis.

With stringent LDV standards already in place for PM from vehicle exhaust, particles from brake and tire wear (BTW) are becoming an increasingly important component of $PM_{2.5}$ emission inventories. To put the magnitude of future BTW $PM_{2.5}$ emissions in perspective, NHTSA conducted MOVES4 analysis using default input values. This analysis indicates that BTW $PM_{2.5}$ represent approximately half of gasoline-fueled passenger car and light truck $PM_{2.5}$ emissions (from vehicle exhaust, brake wear, and tire wear) after 2020.[694] While previous CAFE rulemakings have not modeled the indirect impacts to BTW emissions due to changes in fuel economy and VMT, this rulemaking considers total $PM_{2.5}$ emissions from the vehicle's exhaust, brakes, and tires.

As with downstream emission factors, we generated BTW emission factors using EPA's MOVES4 model.[695] Due to limited BTW measurements, MOVES does not estimate variation in BTW emission factors by vehicle MY, fuel type, or powertrain. Instead, MOVES' estimates of emissions from brake wear are based on weight-based vehicle regulatory classes and operating behavior derived primarily from vehicle speed and acceleration. On the other hand, MOVES' estimates of tire wear emissions depend on the same weight-based regulatory classes, but the effect of operations on emissions is represented only by vehicle speed. Unlike the CAFE Model's downstream emission factors, the BTW estimates were averaged over all vehicle MYs and ages to yield a single grams-per-mile value by regulatory class.

There is some evidence that average vehicle weight will differ by fuel type and powertrain, particularly for longer-range EVs, which are often heavier than a comparable gasoline- or diesel-powered vehicle due to the weight of the battery.[696] This weight increase may result in additional tire wear. While regenerative braking often extends braking systems' useful life and reduces emissions associated with brake wear,[697] the effect of additional mass might be to increase overall BTW emissions.[698] Further BTW field studies are needed to better understand how differences in vehicle fuel and powertrain type are likely to impact $PM_{2.5}$ emissions from BTW. The CAFE Model's BTW inputs can be differentiated by fuel type, but for the time being are assumed to have equivalent values for gasoline, diesel, and electricity. Given the degree to which $PM_{2.5}$ inventories are expected to shift from vehicle exhaust to BTW in the near future, we believe that it is better to have some BTW estimates—even if imperfect—than not to include them at all, as was the case in prior CAFE rulemakings.

In the NPRM, we sought comment on this updated approach and on additional data sources that could be used to update the BTW estimates. Commenters such as the Alliance for Automotive Innovation and Stellantis recommended that NHTSA refrain from including BTW in the analysis until SAE or another organization publishes a measurement methodology and testing procedures for quantifying BTW.[699] Another commenter, the AFPM, stated that new ZEVs specifically would cause an increase in average vehicle weight in the U.S. fleet, and in turn cause more BTW emissions.[700]

With notable reductions in fine particulate matter ($PM_{2.5}$) from tailpipe exhaust due to federal regulation, non-exhaust sources such as brake and tire wear (BTW) constitute a growing proportion of vehicles' $PM_{2.5}$ emissions. Although we agree with commenters that EVs could cause disproportionate brake wear compared to internal combustion engine vehicles due to additional battery weight, it is unclear how this might affect LD and HDPUV PM emissions overall. Without any BEV tailpipe exhaust and some evidence to suggest reduced EV brake wear from regenerative braking, NHTSA has not yet been able to determine the relative PM contributions of BEVs, HEVs, and ICE vehicles. In addition, as discussed in more detail in Section III.D, it appears that the trend for manufacturers to produce large EVs may be declining as manufacturers start building smaller and more affordable EVs. While this final rule continues to project differences in BTW emissions among regulatory classes, there has not been enough new BTW data published since the proposal to update non-exhaust PM emission factors by fuel type. That said, we continue to believe that including the best available data on BTW estimates is better than including no estimates.[701] For further reading on BTW assumptions, please refer to TSD Chapter 5.3.3.4.

The CAFE Model computes select health impacts resulting from population exposure to $PM_{2.5}$. These health impacts include causing or aggravating several different respiratory

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[691] BEVs and FCEVs do not generate any combustion-related emissions.

[692] EPA. 2023. Motor Vehicle Emission Simulator: MOVES4. Office of Transportation and Air Quality. US Environmental Protection Agency. Ann Arbor, MI. August 2023. Available at: *https://www.epa.gov/moves/latest-version-motor-vehicle-emission-simulator-moves* (Accessed: February 2, 2024).

[693] Chapter 3, Section 4 of the CAFE Model Documentation provides additional description for calculation of CO_2 downstream emissions with the model.

[694] For additional information, including figures presenting $PM_{2.5}$ emissions by regulatory class from these MOVES runs, please see TSD 5.3.3.4.

[695] EPA. 2020. Brake and Tire Wear Emissions from Onroad Vehicles in MOVES3. Office of Transportation and Air Quality Assessment and Standards Division, at 1–48. Available at: *https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P1010M43.pdf.* (Accessed Feb. 27, 2024).

[696] Cooley, B. 2022. America's New Weight Problem: Electric Vehicles. CNET. Published: Jan. 28, 2022. Available at: *https://www.cnet.com/roadshow/news/americas-new-weight-problem-electric-cars.* (Accessed: Feb. 27, 2024).

[697] Bondorf, L. et al. 2023. Airborne Brake Wear Emissions from a Battery Electric Vehicle. Atmosphere. Vol. 14(3): at 488. Available at: *https://doi.org/10.3390/atmos14030488.* (Accessed: Feb. 27, 2024).

[698] EPA.2022 Brake Wear Particle Emission Rates and Characterization. Office of Transportation and Air Quality. Available at: *https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P1013TSX.txt.* (Accessed: Feb. 27, 2024); McTurk, E. 2022. Do Electric Vehicles Produce More Tyre and Brake Pollution Than Their Petrol and Diesel Equivalents? RAC. Available at: *https://www.rac.co.uk/drive/electric-cars/running/do-electric-vehicles-produce-more-tyre-and-brake-pollution-than-petrol-and/.* (Accessed: Feb. 27, 2024).

[699] The Alliance, Docket No. NHTSA–2023–0022–60652, at 65–66; Stellantis, Docket No. NHTSA–2023–0022–61107, at 14.

[700] AFPM, Docket No. NHTSA–2023–0022–61911–A2, at 79.

[701] *Ctr. for Biological Diversity* v. *Nat'l Highway Traffic Safety Admin.,* 538 F.3d 1172 (9th Cir. 2008).

conditions and even premature death, each of which is measured by the number of instances predicted to result from exposure to each ton of $PM_{2.5}$-related pollutant emitted (direct PM as well as NO_X and SO_2, both precursors to secondarily-formed $PM_{2.5}$). The CAFE Model reports total $PM_{2.5}$-related health impacts by multiplying the estimated emissions of each $PM_{2.5}$-related pollutant (in tons)—generated using the process described above—by the corresponding health incidence per ton value. Broadly speaking, a health incidence per ton value is the morbidity and mortality estimate linked to an additional ton of an emitted pollutant; these can also be referred to as benefit per ton values where monetary measures of adverse health impacts avoided per ton by which emissions are reduced (discussed further in Section III.G).

The American Lung Association commented on the limits of the health impacts analysis, stating that it ''does not include monetized health harms of ozone, ambient oxides of nitrogen or air toxics.'' [702] We do not include monetized health harms of air toxics as they have not typically been monetized, and as such we currently have no basis for that valuation. The sources used in our health impacts analysis were chosen to best match the pollution source sector categories incorporated in the CAFE Model. For some pollution source sectors, only $PM_{2.5}$ BPT values exist, and as such we chose to consistently measure the same damages across all pollution source sectors by focusing on $PM_{2.5}$-related damages. We plan to revisit this portion of analysis when more source sector BPT values become available in the literature. We do note that these benefits (reduced health harms of ozone, ambient oxides of nitrogen, air toxics) are potentially significant despite not being quantified and have added language to our discussion of benefits of the rule to clarify this.

The health incidence per ton values in this analysis reflect the differences in health impacts arising from the five upstream emission source sectors that we use to generate upstream emissions (petroleum extraction, petroleum transportation, refineries, fuel transportation, storage and distribution, and electricity generation). We carefully examined how each upstream source sector is defined in GREET to appropriately map the emissions estimates to data on health incidences from $PM_{2.5}$-related pollutant emissions. As the health incidences for the different source sectors are all based on the emission of one ton of the same pollutants, NO_X, SO_X, and directly-emitted $PM_{2.5}$, differences in the incidence per ton values arise from differences in the geographic distribution of each pollutant's emissions, which in turn affects the number of people exposed to potentially harmful concentrations of each pollutant.[703]

As in past CAFE analyses, we relied on publicly available scientific literature and reports from EPA and EPA-affiliated authors, to estimate per-ton $PM_{2.5}$-related health damage costs for each upstream source of emissions. We used several EPA reports to generate the upstream health incidence per ton values, as different EPA reports provided more up-to-date estimates for different sectors based on newer air quality modeling. These EPA reports use a reduced-form benefit-per-ton (BPT) approach to assess health impacts; $PM_{2.5}$-related BPT values are the total monetized human health benefits (the sum of the economic value of the reduced risk of premature death and illness) that are expected to result from avoiding one ton of directly-emitted $PM_{2.5}$ or $PM_{2.5}$ precursor such as NO_X or sulfur dioxide (SO_2). We note, however, that the complex, non-linear photochemical processes that govern ozone formation prevent us from developing reduced-form ozone, ambient NO_X, or other air toxic BPT values, an important limitation to recognize when using the BPT approach. We include additional discussion of uncertainties in the BPT approach in Chapter 5.4.3 of the TSD and also conduct full-scale photochemical modeling described in Appendix E of the FEIS. Nevertheless, we believe that the BPT approach provides reasonable estimates of how establishing more stringent CAFE standards is likely to affect public health, and of the value of reducing the health consequences of exposure to air pollution. The BPT methodology and data sources are unchanged from the 2022 CAFE rule, and stakeholders generally agreed that estimates of the benefits of $PM_{2.5}$ reductions were improved from prior analyses based on our emissions-related health impacts methodology updated for that rule.[704]

The reports we relied on for health incidences and BPT estimates include EPA's 2018 technical support document titled Estimating the Benefit per Ton of Reducing $PM_{2.5}$ Precursors from 17 Sectors (referred to here as the 2018 EPA source apportionment TSD),[705] a 2018 oil and natural gas sector paper (Fann et al.), which estimates health impacts for this sector in the year 2025,[706] and a 2019 paper (Wolfe et al.) that computes monetized per ton damage costs for several categories of mobile sources, based on vehicle type and fuel type.[707]

Some CAFE Model upstream emissions components do not correspond to any single EPA source sector identified in available literature, so we used a weighted average of different source sectors to generate those values. Data we used from each paper for each upstream source sector are discussed in detail in Chapter 5.4 of the TSD.

The CAFE Model follows a similar process for computing health impacts resulting from downstream emissions. We used the Wolfe et al. paper to compute monetized damage costs per ton values for several on-road mobile sources categories based on vehicle type and fuel type. Wolfe et al. did not report incidences per ton, but that information was obtained through communications with the study authors. Additional information about how we generated downstream health estimates is discussed in Chapter 5.4 of the TSD.

We are aware that EPA recently updated its estimated benefits for reducing $PM_{2.5}$ from several sources,[708]

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[702] ALA, Docket No. NHTSA–2023–0022–60091, at 2.

[703] EPA. 2018. Estimating the Benefit per Ton of Reducing $PM_{2.5}$ Precursors from 17 Sectors. Office of Air and Radiation and Office of Air Quality Planning and Standards. Research Triangle Park, NC, at 1–108. Available at: *https://www.epa.gov/sites/production/files/2018-02/documents/sourceapportionmentbpttsd_2018.pdf.* (Accessed: Feb. 27, 2024).

[704] CBD et al., Docket No. NHTSA–2021–0053–1572, at 5.

[705] EPA. 2018. Estimating the Benefit per Ton of Reducing $PM_{2.5}$ Precursors from 17 Sectors. Office of Air and Radiation and Office of Air Quality Planning and Standards. Research Triangle Park, NC, at 1–108. Available at: *https://19january2017snapshot.epa.gov/benmap/estimating-benefit-ton-reducing-pm25-precursors-17-sectors_.html.* (Accessed: Feb. 27, 2024).

[706] Fann, N. et al. 2018. Assessing Human Health $PM_{2.5}$ and Ozone Impacts from U.S. Oil and Natural Gas Sector Emissions in 2025. *Environmental Science & Technology.* Vol. 52(15): at 8095–8103. Available at: *https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6718951/.* (Accessed: Feb. 27, 2024) (*hereinafter* Fann et al.).

[707] Wolfe, P. et al. 2019. Monetized Health Benefits Attributable to Mobile Source Emission Reductions Across The United States In 2025. *The Science of the Total Environment.* Vol. 650(Pt 2): at 2490–98. Available at: *https://pubmed.ncbi.nlm.nih.gov/30296769/*) (Accessed: Feb. 27, 2024) (*hereinafter* Wolfe et al.). Health incidence per ton values corresponding to this paper were sent by EPA staff.

[708] EPA. 2023. Estimating the Benefit per Ton of Reducing Directly-Emitted $PM_{2.5}$, $PM_{2.5}$ Precursors

Continued

but those do not include mobile sources (which include the vehicles subject to CAFE and HDPUV fuel efficiency standards). After discussion with EPA staff, we retained the $PM_{2.5}$ incidence per ton values from the previous CAFE analysis for consistency with the current mobile source emissions estimates.

Although we did not discuss doing a quantitative lifecycle analysis in the preamble of the NRPM, several commenters stressed the importance of lifecycle analysis, identified suitable methods for conducting such an analysis, and suggested how the results of such an analysis should factor into the finding that final standards indeed meet the ''maximum feasible'' test. The Agency understands the concern that many commenters have with the potential environmental impacts of vehicle production, including battery material extraction, manufacturing, and end-vehicle and battery disposal. With rapidly expanding EV production, this is a fast-evolving area of research and not one that can be fully addressed in this rule. While some evidence suggests that emissions from vehicle production would likely be greater for EVs than conventionally fueled vehicles, there is also evidence that ICEs continue to have greater total lifecycle emissions than EVs, depending on where the EV is charged. NHTSA is not yet prepared to quantify these relative vehicle cycle impacts. Further investigation across different fuels and vehicle powertrains is warranted and is currently underway with Argonne National Laboratory. For a review of relevant research and additional qualitative discussion on the vehicle cycle and its impacts, readers should refer to FEIS Chapter 6 (Lifecycle Analysis).

G. Simulating Economic Impacts of Regulatory Alternatives

The following sections describe NHTSA's approach for measuring the economic costs and benefits that would result from establishing alternative standards for future MYs. The measures that NHTSA uses are important considerations, because as OMB Circular A–4 states, benefits and costs reported in regulatory analyses must be defined and measured consistently with economic theory and should also reflect how alternative regulations are anticipated to change the behavior of producers and consumers from a baseline scenario. For both the fuel economy and fuel efficiency standards, those include vehicle manufacturers, buyers of new vehicles, owners of used vehicles, and suppliers of fuel, all of whose behavior is likely to respond in complex ways to the level of standards that DOT establishes for future MYs.

A number of commenters asked the agency to more explicitly account for effects that occur in the analytical baseline in the agency's incremental cost-benefit analysis. The agency responds substantively to those comments below. The typical approach to quantifying the impacts of regulations implies that these costs and benefits should be excluded from the incremental cost-benefit analysis given these effects are assumed to occur absent the regulation. Thus, quantifying them in the incremental cost-benefit analysis would obscure the effects the agency needs to isolate in order to analyze the effects of the regulation. For these reasons, the agency does not explicitly account for some of the costs and benefits requested by commenters that accrue in the baseline, and instead focuses on the costs and benefits that may change in response to the final rule.

It is also important to report the benefits and costs of this final rule in a format that conveys useful information about how those impacts are generated, while also distinguishing the economic consequences for private businesses and households from the action's effects on the remainder of the U.S. economy. A reporting format will accomplish this objective to the extent that it clarifies *who* incurs the benefits and costs of the final rule, while also showing how the economy-wide or ''social'' benefits and costs of the final rule are composed of direct effects on vehicle producers, buyers, and users, plus the indirect or ''external'' benefits and costs it creates for the general public. NHTSA does not attempt to distinguish benefits and costs into co-benefits or secondary costs.

Table III–7 lists the economic benefits and costs analyzed in conjunction with this final rule, and where to find explanations for what we measure, why we include it, how we estimate it, and the estimated value for that specific line item. The table also shows how the different elements of the analysis piece together to inform NHTSA's estimates of private and external costs and benefits.[709]

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and Ozone Precursors from 21 Sectors. Last updated: Jan. 2023. Available at: *https://www.epa.gov/benmap/estimating-benefit-ton-reducing-directly-emitted-pm25-pm25-precursors-and-ozone-precursors.* (Accessed: Feb. 27, 2024).

Table III-7: Benefits and Costs Resulting from NHTSA's Regulatory Action[710]

Entry	Section of Preamble Discussion	Chapter of TSD Modeling Explanation	Chapter of FRIA Discussion	Chapter of FRIA Results
Private Costs				
Technology Costs to Increase Fuel Economy	II.G.1.a(1)	Chapter 6.1	Chapter 7.1.1	Chapters 8.2.3.1 and 8.3.3.1
Consumer Surplus Loss from Reduced New Vehicle Sales	II.G.1.a(2)	Chapter 6.1.2	Chapter 7.1.4	Chapters 8.2.2.3, 8.2.3.2, 8.3.2.3 and 8.3.3.2
Increased Maintenance and Repair Costs	II.G.3	-	Chapter 7.1.1	-
Sacrifice in Other Vehicle Attributes	II.G.3	-	Chapters 7.1.1 and 9.2.3.10	Chapters 9.2.3.9 and 9.2.3.10
Safety Costs Internalized by Drivers	II.H.3	Chapter 7.5	Chapters 7.1.5, 8.5.5	Chapters 8.2.4.5 and 8.3.4.5
Subtotal—Internal Costs				Sum of above entries
External and Government Costs				
Congestion and Noise Costs from Rebound-Effect Driving	II.G.2.a(1)	Chapter 6.2.3	Chapter 7.2.2	Chapters 8.2.4.3 and 8.3.4.3
Loss in Fuel Tax Revenue	II.G.2.a(2)	Chapters 6.1.3, 6.2	Chapter 7.3.1	Chapters 8.2.4.6 and 8.3.4.6
Safety Costs Not Internalized by Drivers	II.H.1 and II.H.2	Chapter 7	Chapters 7.1.5, 8.5.5	Chapters 8.2.4.5 and 8.3.4.5
Subtotal – External Costs				Sum of above entries
Social Costs				Sum of private and external costs
Private Benefits				
Savings in Retail Fuel Costs[711]	II.G.1.b(1)	Chapter 6.1.3	Chapter 7.3.1	Chapters 8.2.2.2, 8.2.2.3, and 8.3.2.2, 8.3.2.3
Less Frequent Refueling	II.G.1.b(2)	Chapter 6.1.4	Chapter 8.4.2	Chapters 8.2.2.3 and 8.3.2.3
Benefits from Additional Driving	II.G.1.b(3)	Chapter 6.1.5	Chapter 7.2.1	Chapters 8.2.3.2 and 8.3.3.2
Subtotal – Private Benefits				Sum of above entries
External and Government Benefits				

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NHTSA reports the costs and benefits of standards for LDVs and HDPUVs separately. While the effects are largely the same for the two fleets, our fuel economy and fuel efficiency programs are separate, and NHTSA makes independent determinations of the maximum feasible standards for each fleet.

A standard function of regulatory analysis is to evaluate tradeoffs between impacts that occur at different points in time. Many Federal regulations involve costly upfront investments that generate future benefits in the form of reductions in health, safety, or environmental damages. To evaluate these tradeoffs, the analysis must account for the social rate of time preference—the broadly observed social preference for benefits that occur sooner versus those that

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[709] Changes in tax revenues are a transfer and not an economic externality as traditionally defined, but we group these with external costs instead of private costs since that loss in revenue affects society as a whole as opposed to impacting only consumers or manufacturers.

[710] This table presents the societal costs and benefits. Costs and benefits that affect only the consumer analysis, such as sales taxes, insurance costs, and reallocated VMT, are purposely ommited from this table. See Chapters 8.2.3 and 8.3.3 of the FRIA for consumer-specific costs and benefits.

[711] Since taxes are transfers from consumers to governments, a portion of the Savings in Retail Fuel Costs includes taxes avoided. The Loss in Fuel Tax Revenue is completely offset within the Savings in Retail Fuel Costs.

occur further in the future. This is accomplished by discounting impacts that occur further in the future more than impacts that occur sooner.

OMB Circular A–4 (2003) affirms the appropriateness of accounting for the social rate of time preference in regulatory analyses and recommends discount rates of 3 and 7 percent for doing so. The recommended 3 percent discount rate was chosen to represent the ''consumption rate of interest'' approach, which discounts future costs and benefits to their present values using the rate at which consumers appear to make tradeoffs between current consumption and equal consumption opportunities when deferred to the future. OMB Circular A–4 (2003) reports an inflation-adjusted or ''real'' rate of return on 10-year Treasury notes of 3.1 percent between 1973 and its 2003 publication date and interprets this as approximating the rate at which society is indifferent between consumption today and in the future. The 7 percent rate reflects the opportunity cost of capital approach to discounting, where the discount rate approximates the forgone return on private investment if the regulation were to divert resources from capital formation. Fuel savings and most other benefits from tightening standards will be experienced directly by owners of vehicles that offer higher fuel economy and thus affect their future consumption opportunities, while benefits or costs that are experienced more widely throughout the economy will also primarily affect future consumption. Circular A–4 indicates that discounting at the consumption rate of interest is the ''analytically preferred method'' when effects are presented in consumption-equivalent units. Thus, applying OMB's guidance to NHTSA's final rule suggests the 3 percent rate is the appropriate rate. However, NHTSA reports both the 3 and 7 percent rates for transparency and completeness. It should be noted that the OMB finalized a revision to Circular A–4 on November 9th, 2023. The 2023 Circular A–4 is effective for NPRMs, IFRs, and direct final rules submitted to OMB on or after March 1st, 2024, while the effective date for other final rules is January 1st, 2025. Thus, while NHTSA has considered the guidance in the revised circular for the final rule, as this final rule will be published before January 1, 2025, the agency will continue to use the discount rates in the prior version for the primary analysis.[712] The agency performed a sensitivity case using a 2 percent social discount rate consisted with the guidance of revised Circular A–4 (2023) which can be found in Chapter 9 of the RIA.

A key exception to Circular A–4's guidance on social discounting implicates the case of discounting climate related impacts. Because some GHGs emitted today can remain in the atmosphere for hundreds of years, burning fossil fuels today not only imposes uncompensated costs on others around the globe today, but also imposes uncompensated damages on future generations. As OMB Circular A–4 (2003) indicates ''special ethical considerations arise when comparing benefits and costs across generations'' and that future citizens impacted by a regulatory choice ''cannot take part in making them, and today's society must act with some consideration of their interest.''[713] Thus, NHTSA has elected to discount these effects from the year of abatement back to the present value with lower rates. For further discussion, see Section III.G.2.b(1) of the Preamble.

For a complete discussion of the methodology employed and the results, see Chapter 6 of the TSD and Chapter 8 of the RIA, respectively. The safety implications of the final rule—including the monetary impacts—are reserved for Section III.H.

1. Private Costs and Benefits

a. Costs to Consumers

(1) Technology Costs

The technology applied to meet the standards would increase the cost to produce new cars, light trucks and HDPUVs. Within this analysis, manufacturers are assumed to transfer these costs to the consumers who purchase vehicles offering higher fuel economy. While NHTSA recognizes that some manufacturers may defray their regulatory costs for meeting increased fuel economy and fuel efficiency standards through more complex pricing strategies or by accepting lower profits, NHTSA lacks sufficient insight into manufacturers' pricing strategies to confidently model alternative approaches. Thus, we simply assume that manufacturers raise the prices of models whose fuel economy they elect to improve sufficiently to recover their increased costs for doing so. The technology costs are incurred by manufacturers and then passed onto consumers. While we include the effects of IRA tax credits in our modeling of consumer responses to the standards, the effect of the tax credit is an economic transfer where the costs to one party are exactly offset by benefits to another and have no impact on the net benefits of the final rule. While NHTSA could include IRA tax credits as a reduction in the technology costs for manufacturers and purchasing prices in our cost-benefit accounting, tax credits are a transfer from the government to private parties, and as such have no net effect on the benefits or costs of the final rule. As such, the line item included in the tables summarizing the cost of technology throughout this final rule should be considered pre-tax unless otherwise noted.

NHTSA did not receive comments pertaining to this topic. See Section III.C.6 of this preamble and Chapter 2.5 of the TSD for more details.

(2) Consumer Sales Surplus

Consumers who forgo purchasing a new vehicle because of the increase in the price of new vehicles' prices caused by more stringent standards will experience a decrease in welfare. The collective welfare loss to these ''potential'' new vehicle buyers is measured by their foregone consumer surplus.

Consumer surplus is a fundamental economic concept and represents the net value (or net benefit) a good or service provides to consumers. It is measured as the difference between what a consumer is willing to pay for a good or service and its market price. OMB Circular A–4 explicitly identifies consumer surplus as a benefit that should be accounted for in cost-benefit analysis. For instance, OMB Circular A–4 states the ''net reduction in total surplus (consumer plus producer) is a real cost to society,'' and elsewhere recommends that consumer surplus values be monetized ''when they are significant.''

Accounting for the limited portion of lifetime fuel savings that the average new vehicle buyer values, and holding all else equal, higher average prices should depress new vehicle sales and by extension reduce consumer surplus. The inclusion of the effects on the final rule on consumer surplus is not only consistent with OMB guidance, but with other parts of this regulatory analysis. For instance, we calculate the increase in consumer surplus associated with increased driving that results from the lower CPM of driving under more stringent regulatory alternatives, as discussed in Section II.G.1.b(3). The

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[712] That is, NHTSA did not incorporate the new recommendations about social discounting at 2 percent into the primary analysis but has included a senstivity with this discount rate.

[713] The Executive Office of the President's Office of Management and Budget. 2003. Circular No. A–4. Regulatory Analysis. Available at: *https://www.whitehouse.gov/wp-content/uploads/legacy_drupal_files/omb/circulars/A4/a-4.pdf.*

surpluses associated with sales and additional mobility are inextricably linked, as they capture the direct costs and benefits to purchasers of new vehicles. The sales surplus captures the welfare loss to consumers when they forego purchasing new vehicles because of higher prices, while the consumer surplus associated with additional driving measures the benefit of the increased mobility it provides.

NHTSA estimates the loss of sales surplus based on the change in quantity of vehicles projected to be sold, after adjusting for quality improvements attributable to higher fuel economy or fuel efficiency. Several commenters mention that there may be distributional impacts in terms of the less financially privileged not being able to afford higher priced vehicles.[714] Consumers in rural areas are specifically mentioned as being adversely affected due to the higher cost of charging an EV in rural areas which would presumably act as a barrier to purchasing one of these vehicles.[715]

While these commenters allege that consumers will be harmed by the inability to purchase new vehicles because of the regulations, commenters did not provide any evidence to support that these effects will, or even likely to occur, and seemingly ignored how these communities may value and benefit from reduced operational costs. Regardless, NHTSA accounted for the possibility that there would be a change in welfare associated with decreased sales, but NHTSA did not receive any comments suggesting that its estimation of the consumer sales surplus was inadequate. Nor did any commenters suggest changes to the agency's methodology. As such, the agency has elected to use the same methodology as the proposal and feels that the lost welfare from the consumer sales surplus adequately captures the effects raised by commenters. Furthermore, the IRA provides a 30% tax credit for qualified alternative fuel vehicle refueling property supporting the installation of charging infrastructure in low-income and non-urban areas.[716] For additional information about consumer sales surplus, see Chapter 6.1.2 of the TSD.

(3) Ancillary Costs of Higher Vehicle Prices

Some costs of purchasing and owning a new or used vehicle increase in proportion to its purchase price or market value. At the time of purchase, the price of the vehicle combined with the state-specific tax rate determine the sales tax paid. Throughout the lifetime of the vehicle, the residual value of the vehicle—which is determined by its initial purchase price, age, and accumulated usage—determine value-related registration fees and insurance premiums. The analysis assumes that the transaction price is a fixed share of the MSRP, which allows calculation of these factors as shares of MSRP. As the standards influence the price of vehicles, these ancillary costs will also increase. For a detailed explanation of how NHTSA estimates these costs, see Chapter 6.1.1 of the TSD. These costs are included in the consumer per-vehicle cost-benefit analysis but not in the societal cost-benefit analysis, because they are assumed to be transfers from consumers to government agencies or to reflect actuarially ''fair'' insurance premiums. NHTSA did not receive any comments about its treatment of state sales taxes or changes to insurance premiums.

In previous proposals and final rules, NHTSA also included the costs of financing vehicle purchases as an ancillary cost to consumers. However, as we noted in the 2022 final rule, the availability of vehicle financing offers a benefit to consumers by spreading out the costs of additional fuel economy technology over time. Thus, we no longer include financing as a cost to consumers. Lucid supports NHTSA's decision to exclude financing as an ancillary cost,[717] recognizing the benefit of smoothing out consumer costs over time. NADA and MEMA have mentioned that the majority of prospective new vehicle purchasers finance their transactions, and expressed concern that higher interest rates may be impacting the affordability of financing and that consumer credit may not reach to meet changing vehicle prices.[718] NHTSA has determined it is appropriate to continue to exclude these costs from the analysis for the following reasons. With regards to the impact of increasing vehicle purchasing costs, as previously mentioned, NHTSA calculates and includes the change in consumer surplus of those who choose not to purchase a new vehicle as a result of higher vehicle prices due to the stringency of the standards. In addition, explicitly modeling future long-run changes in financing costs due to changes in interest rates is a technically uncertain undertaking and outside the current bounds of this work. Forecasting long-run interest rates includes making a variety of assumptions on the structure that these rates might take, such as a random walk or equivalence to a forward rate and are subject to numerous exogenous macroeconomic factors and uncertainties. Commenters did not identify any long-run projections that supported their conclusions pertaining to this aspect of consumer costs. Therefore, it is inaccurate to assume that high interest rates at one point in time will lead to higher rates (and therefore higher costs) for all consumers during the regulatory period.

b. Benefits to Consumers

(1) Fuel Savings

The primary benefit to consumers of increasing standards is the savings in future fuel costs that accrue to buyers and subsequent owners of new vehicles. The value of fuel savings is calculated by multiplying avoided fuel consumption by retail fuel prices. Each vehicle of a given body style is assumed to be driven the same amount in each year of its lifetime as all those of comparable age and body style. The ratio of that cohort's annual VMT to its fuel efficiency produces an estimate of its yearly fuel consumption. The difference between fuel consumption in the No-Action Alternative, and in each regulatory alternative, represents the gallons (or energy content) of fuel saved.

Under this assumption, our estimates of fuel consumption from increasing the fuel economy or fuel efficiency of each individual model depend only on how much its fuel economy or efficiency is increased, and do not reflect whether its actual use differs from other models of the same body type. Neither do our estimates of fuel consumption account for variation in how much vehicles of the same body type and age are driven each year, which appears to be significant (see Chapter 4.3.1.2 of the TSD). Consumers save money on fuel expenditures at the average retail fuel price (fuel price assumptions are discussed in detail in Chapter 4.1.2 of the TSD), which includes all taxes and represents an average across octane blends. For gasoline and diesel, the included taxes reflect both the Federal tax and a calculated average state fuel tax. Expenditures on alternative fuels

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[714] AFPM, Docket No. NHTSA–2023–0022–61911, at 61–63; Heritage Foundation-Mario Loyola, Docket No. NHTSA–2023–0022–61952, at 7–13; American Consumer Institute, Docket No. NHTSA–2023–0022–50765, at 2.

[715] NCB, Docket No. NHTSA–2023–0022–53876, at 2.

[716] Internal Revenue Service, Alternative Fuel Vehicle Refueling Property Credit, May 9, 2024. *https://www.irs.gov/credits-deductions/alternative-fuel-vehicle-refueling-property-credit.*

[717] Lucid, Docket No. NHTSA–2023–0022–50594, at 6.

[718] NADA, Docket No. NHTSA–2023–0022–58200, at 6–8; MEMA, Docket No. NHTSA–2023–0022–59204, at 9.

(E85 and electricity, primarily) are also included in the calculation of fuel expenditures, on which fuel savings are based. However, since alternative fuel technology is not applied to meet the standards, the majority of the costs associated with operating alternative fuels net to zero between the reference baseline and action alternatives. And while the included taxes net out of the social benefit cost analysis (as they are a transfer), consumers value each gallon saved at retail fuel prices including any additional fees or taxes they pay.

Chapter 6.1.3 of the TSD provides additional details. As explained in the TSD, NHTSA considers the possibility that several of the assumptions made about vehicle use could lead to misstating the benefits of fuel savings. NHTSA notes that these assumptions are necessary to model fuel savings and likely have minimal impact to the accuracy of the analysis for this final rule.

A variety of commenters discussed how fuel savings are valued by both manufacturers and consumers, with some discussion on whether NHTSA has under or over-valued the benefits to consumers, the appropriate use of discount rate to apply to fuel savings, and the source of data used to project fuel savings. AEI commented that the ''inclusion of fuel savings is illegitimate as a component of the 'benefits' the [rule] because the economic benefits of fuel savings are captured fully by consumers of the fuel.'' [719] Conversely, IPI commented that including all fuel savings as a benefit of the rule is appropriate because the rule is addressing the energy efficiency gap.

NHTSA agrees with IPI that fuel savings should be accounted for within the rule. AEI's comment is premised on the theory that the vehicle market is efficient and therefore consumers *must not* value fuel savings, and NHTSA's regulations may only address market failures that address externalities. As discussed in III.E, the energy efficiency gap has long been recognized as a market failure that may impact the ability of consumers to realize fuel savings. Furthermore, the notion that only externalities may be counted as a benefit is unfounded. Executive Order 12866 and Circular A–4 (2003) have long required agencies to attempt to quantify *as many* benefits as possible and costs that can reasonably be ascertained and quantified into its analysis, and courts have frowned upon federal agencies ignoring known and quantifiable costs or benefits.[720] In addition, how the agency quantifies and monetizes this benefit is not the same as how the agency considers it in making its determination of what standards are ''maximum feasible,'' and thus the extent to which the agency should consider consumer fuel savings is addressed in that discussion.

NADA commented that ''NHTSA correctly noted that EV owners will save refueling time by charging at home, but the analysis is flawed in that it does not account for the impact of increased electricity consumption and related expenditures for those who charge at home.'' [721] NADA is incorrect in their assertion that NHTSA ignores the cost of recharging at home. The fuel savings benefit is derived from all fuel sources consumed—including electricity—and is intended to capture the total cost spent to refuel and recharge in each alternative.

Some commenters argued that NHTSA's use of static electricity price projections could lead to an underestimate of the operating costs of BEVs. The Heritage Foundation and NADA both argued that increased demand for electricity induced by BEV adoption—which happens solely in the analytical reference baseline through the end of the standard setting years—would necessitate increased investment in the electricity grid and thus lead to higher electricity prices to recover the costs of these investments.[722] The Heritage Foundation also suggested that NHTSA's cost-benefit analysis should account for incremental infrastructure costs required to comply with changes to the standards. NHTSA believes it is properly accounting for the impact of greater penetration of BEVs on electricity prices in its regulatory analysis. The electricity prices used in its analysis are taken from AEO 2023 and represent EIA's best projection of how greater electrification in the automobile market will impact electricity prices. Due to its statutory constraints under EPCA, NHTSA does not permit production of BEVs as a compliance strategy during model years for which it is establishing standards, which restricts BEV adoption to the reference baseline. NHTSA believes that the modest difference in projected adoption of BEVs between even the most stringent alternatives and the reference baseline is unlikely to necessitate significant additional investment in the electricity generation and distribution grid beyond the No-Action Alternative, and thus will have only minimal effects on electricity prices. NHTSA's choice not to account for potential effects of its standards on future electricity prices in its analysis of costs and benefits is consistent with the agency's treatment of fuel prices, which is discussed in TSD Chapter 6.2.4.

Some commenters, such as the Center for Environmental Accountability, argued that electricity prices charged to users of public charging stations are somewhat higher on average than those of at home charging.[723] NHTSA believes that at-home charging will continue to be the primary charging method during the time period relevant to this rulemaking, and thus residential electricity rates are the most representative electricity prices to use in our analysis. However, the agency notes again that electrification is restricted to the reference baseline through the standard setting years, accounting for the price difference between at-home versus public charging would result in minor differences between the alternatives that would have little impact in changing the net benefits of any of the scenarios.

Finally, there is some discussion among the commenters related to the appropriate choice of discount rate to apply to fuel savings. Valero suggests that valuing medium-term impacts at a discount rate of 3 percent is inappropriate due to the consumer's investment perspective,[724] while CEA suggests that a 7 percent discount rate is a more appropriate choice over 3 percent due to differences paid for risk-free versus risky assets.[725] Consumer Reports supports the use of a 3 percent discount rate in its calculation of discounted net savings for the consumer in the medium term.[726]

NHTSA believes that is appropriate to account for fuel savings with the same 3 and 7 percent discount rates used for other costs and benefits, such as technology costs which are also accrued by consumers. This approach, as explained in Circular A–4,[727] captures

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[719] AEI, Docket No. NHTSA–2023–0022–54786, at 9–10.

[720] E.O. 12866 at 2, 7; Circular A4 (2003) under D. Analytical Approaches (Benefit-Cost Analysis); *CBD* v. *NHTA,* 538 F.3d 1172, 1198 (9th Cir. 2008).

[721] NADA, Docket No. NHTSA–2023–0022–58200–A1, at 10.

[722] Heritage Foundation-Mario Loyola, Docket No. NHTSA–2023–0022–61952, at 13–14; NADA, Docket No. NHTSA–2023–0022–58200, at 9–11.

[723] NATSO et al, Docket No. NHTSA–2023–0022–61070, at 7–8.

[724] Valero, Docket No. NHTSA–2023–0022–58547, Attachment F, at 1.

[725] CEA, Docket No. NHTSA–2023–0022–61918, at 23.

[726] Consumer Reports, Docket No. NHTSA–2023–0022–61098, at 11.

[727] The Executive Office of the Present's Office of Management and Budget. 2003. Circular No. A–4. Regulatory Analysis. Available at: *https://www.whitehouse.gov/wp-content/uploads/legacy_*

discount rates that reflect different preferences, and looking at both rates provides policy makers a more well-informed perspective. It is important to note that NHTSA's assumptions regarding how consumers value fuel savings at the time of new vehicle purchase do not apply to how NHTSA values fuel savings in its benefit-cost analysis. The prior discussion of the energy efficiency gap and consumer's undervaluation of lifetime fuel savings relates to the consumer decision in the vehicle market. NHTSA's societal-level benefit cost analysis includes the full lifetime fuel savings discounted using both 3 and 7 percent discount rates. Additional detail can be found in Chapter 4.2.1.1 of the TSD.

(2) Refueling Benefit

Increasing standards affects the amount of time drivers spend refueling their vehicles in several ways. First, higher standards increase the fuel efficiency of ICE vehicles produced in the future, which may increase their driving range and decrease the number of refueling events. Conversely, to the extent that more stringent standards increase the purchase price of new vehicles, they may reduce sales of new vehicles and scrappage of existing ones, causing more VMT to be driven by older and less efficient vehicles that require more refueling events for the same amount of driving. Finally, as the number of EVs in the fleet increases, some of the time spent previously refueling ICE vehicles at the pump will be replaced with recharging EVs at public charging stations. While the analysis does not allow electrification to be chosen as a compliance pathway with the standards for LDVs, it is still important to model recharging since excluding these costs would underestimate scenarios with additional BEVs, such as our sensitivity cases that examine lower battery costs.

NHTSA estimates these savings by calculating the amount of refueling time avoided—including the time it takes to locate a retail outlet, refuel one's vehicle, and pay—and multiplying it by DOT's estimated value of travel time. For a full description of the methodology, refer to Chapter 6.1.4 of the TSD. An alternative hypothesis NHTSA is still considering, but not adopting for the final rule, is whether manufacturers maintain vehicle range by lowering tank size as vehicle efficiency improves without, therefore, reducing refueling time.

NADA commented that the agency's assumption that EVs will only be recharged when necessary mid-trip is inaccurate. NADA noted that ‘‘many BEV owners and operators, particularly those living in urban areas, will not charge at home.’’ [728] As noted earlier, NHTSA believes that most charging will occur in the home during time period relevant to this rulemaking, but NHTSA agrees with NADA that not all EV owners may have access to home charging.[729] Commenters did not come forward with any specifics of how to best quantify these costs, but we may revisit these assumptions in the future when more information is available. For the time being, the agency believes that, even if it were to quantify the recharging time of EVs for non-mid-trip refuelings, the differences between the alternatives would be negligible given most of those costs would be incurred in the reference baseline.

(3) Additional Mobility

Any increase in travel demand provides benefits that reflect the value to drivers and passengers of the added—or more desirable—social and economic opportunities that additional travel makes available. Under each of the alternatives considered in this analysis, the fuel CPM of driving would decrease as a consequence of higher fuel economy and efficiency levels, thus increasing the number of miles that buyers of new cars, light trucks, and HDPUVs would drive as a consequence of the well-documented fuel economy rebound effect.

In theory, the decision by drivers and their passengers to make more frequent or longer trips when the cost of driving declines demonstrates that the benefits that they gain by doing so must exceed the costs they incur. At a minimum, one would expect the benefits of additional travel to equal the cost of the fuel consumed to travel additional miles (or they would not have occurred). Because the cost of that additional fuel is reflected in the simulated fuel expenditures, it is also necessary to account for the benefits associated with those extra miles traveled. But those benefits arguably should also offset the economic value of their (and their passengers') travel time, other vehicle operating costs, and the economic cost of safety risks due to the increase in exposure to crash risks that occurs with additional travel. The amount by which the benefit of this additional travel exceeds its economic costs measures the net benefits drivers and their passengers experience, usually referred to as increased consumer surplus.

Chapter 6.1.5 of the TSD explains NHTSA's methodology for calculating benefits from additional mobility. The benefit of additional mobility over and above its costs is measured by the change in consumers' surplus, which NHTSA approximates as one-half of the change in fuel CPM times the increase in VMT due to the rebound effect. In the proposal, NHTSA sought comments on the assumptions and methods used to calculate benefits derived from additional mobility. NHTSA received several comments addressing its approach for estimating the total change in VMT caused by changes in the standard. These comments are addressed in section III.E. However, NHTSA did not receive comments on its methodology for quantifying the related change in benefits from additional mobility.

When the size of the vehicle stock decreases in the LD alternative cases, VMT and fuel cost per-vehicle increase. Because maintaining constant non-rebound VMT assumes consumers are willing to pay the full cost of the reallocated vehicle miles, we offset the increase in fuel cost per-vehicle in the LD analysis by adding the product of the reallocated VMT and fuel CPM to the mobility value in the per-vehicle consumer analysis. Because we do not estimate other changes in cost per-vehicle that could result from the reallocated miles (*e.g.,* maintenance, depreciation, etc.) we do not estimate the portion of the transferred mobility benefits that would correspond to con'umers' willingness to pay for those costs. We do not estimate the con'umers' surplus associated with the reallocated miles because there is no change in total non-rebound VMT and thus no change in con'umers' surplus per consumer. Chapter 6.1.5 of the TSD explains NHTSA's methodology for calculating the benefits of reallocated miles. NHTSA sought comment in the proposal on its methodology for calculating the benefits from reallocated milage. NHTSA did not receive comments on this subject.

2. External Costs and Benefits

a. Costs

(1) Congestion and Noise

Increased vehicle use associated with the rebound effect also contributes to increased traffic congestion and

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drupal_files/omb/circulars/A4/a-4.pdf (Accessed: Mar. 11, 2024).

[728] NADA, Docket No. NHTSA–2023–0022–58200, at 10.

[729] NHTSA disagrees with NADA's ancillary comment that public infrastructure is insufficient, and the agency believes it is more than likely that some of who do not have access to home charging may have charging options while at work or some other routine public destination.

highway noise. Although drivers obviously experience these impacts, they do not fully value their effects on other travelers or bystanders, just as they do not fully value the emissions impacts of their own driving. Congestion and noise costs are thus ''external'' to the vehicle owners whose decisions about how much, where, and when to drive more in response to changes in fuel economy result in these costs. Thus, unlike changes in the costs incurred by drivers for fuel consumption or safety risks they willingly assume, changes in congestion and noise costs are not offset by corresponding changes in the travel benefits drivers experience.

Congestion costs are limited to road users; however, since road users include a significant fraction of the U.S. population, changes in congestion costs are treated as part of the final rule's external economic impact on society as a whole instead of as a cost to private parties. Costs resulting from road and highway noise are even more widely dispersed because they are borne partly by surrounding residents, pedestrians, and other non-road users, and for this reason are also considered as costs that drivers impose on society as a whole.

To estimate the economic costs associated with changes in congestion and noise caused by increases in driving, NHTSA updated the estimates of per-mile congestion and noise costs from increased automobile and light truck use reported in FHWA's 1997 Highway Cost Allocation Study to account for changes in travel activity and economic conditions since they were originally developed, as well as to express them in 2021 dollars for consistency with other economic inputs. NHTSA employed a similar approach for the 2022 final rule. Because HDPUVs and light-trucks share similar operating characteristics, we also apply the noise and congestion cost estimates for light-trucks to HDPUVs.

See Chapter 6.2 of the TSD for details on how NHTSA calculated estimates of the economic costs associated with changes in congestion and noise caused by differences in miles driven. In the NPRM, NHTSA requested comment on the congestion costs employed in this analysis, but we did not receive any and have not changed our methodology from the NPRM for this final rule.

(2) Fuel Tax Revenue

As mentioned in Section II.G.1.b(1), a portion of the fuel savings experienced by consumers includes avoided fuel taxes. While fuel taxes are a transfer and do not affect net benefits, NHTSA reports an estimate of changes in fuel tax revenues together with external costs to show the potential impact on state and local government finances.

Several commenters, including AHUA and the ID, MT, ND, SD, and WY DOTs, discussed changes in the Highway Trust Fund as a result of changes in gasoline tax payment by consumers, and mentioned concern in funding for highway infrastructure, a potential cost that was not incorporated or accounted for in the rule.[730] NHTSA reports changes in gasoline tax payments by consumers and in revenues to government agencies, and NHTSA's proposal explained in multiple places that gasoline taxes are considered a transfer—a cost to governments and an identical benefit to consumers that has already been accounted for in reported fuel savings—and have no impact on net benefits. As indicated above, any reduction in tax revenue received by governments that levy taxes on fuel is exactly offset by lower fuel tax payments by consumers, so from an economy-wide standpoint reductions in gasoline tax revenues are simply a transfer of economic resources and has no effect on net benefits. The agency notes that a decrease in revenue from gasoline taxes does not preclude alternative methods from funding the Highway Trust Fund or infrastructure,[731] and—while fiscal policy is outside the scope of this rulemaking—some of the more hyperbolic claims that less fuel taxes ''would threaten the viability of the national highway system'' are clearly unfounded.[732]

b. Benefits

(1) Climate Benefits

The combustion of petroleum-based fuels to power cars, light trucks, and HDPUVs generates emissions of various GHGs, which contribute to changes in the global climate and resulting economic damages. Extracting and transporting crude petroleum, refining it to produce transportation fuels, and distributing fuel all generate additional emissions of GHGs and criteria air pollutants beyond those from vehicle usage. By reducing the volume of petroleum-based fuel produced and consumed, adopting standards will thus mitigate global climate-related economic damages caused by accumulation of GHGs in the atmosphere, as well as the more immediate and localized health damages caused by exposure to criteria pollutants. Because they fall broadly on the U.S. population, and on the global population as a whole in the case of climate damages, reducing GHG emissions and criteria pollutants represents an external benefit from requiring higher fuel economy.

(a) Social Cost of Greenhouse Gases Estimates

NHTSA estimated the climate benefits of CO_2, CH_4, and N_2O emission reductions expected from the proposed rule using the Interagency Working Group's (IWG) interim SC–GHG estimates presented in the Technical Support Document: SC of Carbon (SCC), Methane, and Nitrous Oxide Interim Estimates (''February 2021 TSD''). NHTSA noted in the proposal that E.O. 13990 envisioned these estimates to act as a temporary surrogate until the IWG could finalize new estimates. NHTSA acknowledged in the proposal that our understanding of the SC–GHG is still evolving and that the agency would continue to track developments in the economic and environmental sciences literature regarding the SC of GHG emissions, including research from Federal sources like the EPA.[733] NHTSA sought comment on whether an alternative approach should be considered for the final rule.

On December 22, 2023, the IWG issued a memorandum to Federal agencies, directing them to ''use their professional judgment to determine which estimates of the SC–GHG reflect the best available evidence, are most appropriate for particular analytical contexts, and best facilitate sound decision-making.'' [734] NHTSA determined that the 2023 EPA SC–GHG Report for the final rule would be the most appropriate estimate to use for the final rule.[735]

NHTSA arrived at this decision for several reasons. E.O. 13990 tasked the IWG with devising long-term recommendations to update the methodologies used in calculating these SC–GHG values, based on ''the best available economics and science,'' and incorporating principles of ''climate

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[730] AHUA, Docket No. NHTSA–2023–0022–58180, at 8; State DOTs, Docket No. NHTSA–2023–0022–60034, at 1–2.

[731] *See, e.g.,* the Bipartisan Infrastructure Bill, Public Law 117–58, which provided over 300 billion to repair and rebuild American roads.

[732] Heritage Foundation-Mario Loyola, Docket No. NHTSA–2023–0022–61952, at 14.

[733] *See* 88 FR 56251.

[734] Memorandum from the Interagency Working Group on Social Cost of Greenhouse Gases, *avalaible at https://www.whitehouse.gov/wp-content/uploads/2023/12/IWG-Memo-12.22.23.pdf* (Accessed: April 16, 2024).

[735] US Environmental Protection Agency (EPA) ''Report on the Social Cost of Greenhouse Gases Estimates Incorporating Recent Scientific Advances'' (2023) (Final 2023 Report), *https://www.epa.gov/system/files/documents/2023-12/epa_scghg_2023_report_final.pdf* (Accessed: March 22, 2024) (hereinafter 2023 EPA SC–GHG Report).

risk, environmental justice (EJ), and intergenerational equity.'' The E.O. also instructed the IWG to take into account recommendations from the National Academies of the Sciences (NAS) committee convened on this topic, which were published in 2017.[736] Specifically, the National Academies recommended that the SC–GHG should be developed using a modular approach, where the separate modules address socioeconomic projections, climate science, economic damages, and discounting. The NAS recommended that the methodology underlying each of the four modules be updated by drawing on the latest research and expertise from the scientific disciplines relevant to that module.

The 2023 EPA SC–GHG Report presents a set of SC–GHG estimates that incorporate the National Academies' near-term recommendations and reflects the most recent scientific evidence. The report was also subject to notice, comment, and a peer review to ensure the quality and integrity of the information it contains and concluded after NHTSA issued its proposal.[737] NHTSA specifically cited EPA's proposed estimates and final external peer review report on EPA's draft methodology in its proposal, as that was the most up-to-date version of the estimates available as of the date of NHTSA's proposal.[738] Several commenters, including IPI, suggested that the agency use EPA's estimates for the final rule. This is further discussed in subsection (c) of this Climate Benefits section. NHTSA believes the 2023 EPA SC–GHG Report represent the most comprehensive SC–GHGs estimates currently available. For additional details, see Chapter 6.2.1.1 of the TSD.

(b) Discount Rates for Climate Related Benefits

As mentioned earlier, NHTSA discounts non-climate benefits and costs at both the 3% consumption rate of interest and the 7% opportunity cost of capital, in accordance with OMB Circular A–4 (2003). Because GHGs degrade slowly and accumulate in the earth's atmosphere, the economic damages they cause increase as their atmospheric concentration accumulates. Some GHGs emitted today will remain in the atmosphere for hundreds of years, therefore, burning fossil fuels today not only imposes uncompensated costs on others around the globe today, but also imposes uncompensated damages on future generations. As OMB Circular A–4 (2003) indicates ''special ethical considerations arise when comparing benefits and costs across generations'' and that future citizens impacted by a regulatory choice ''cannot take part in making them, and today's society must act with some consideration of their interest.'' [739] As the EPA's report states, ''GHG emissions are stock pollutants, in which damages result from the accumulation of the pollutants in the atmosphere over time. Because GHGs are long-lived, subsequent damages resulting from emissions today occur over many decades or centuries, depending on the specific GHG under consideration.'' [740] NHTSA's analysis is consistent with the notion that intergenerational considerations merit lower discount rates for rules such as CAFE with impacts over very long-time horizons.

In addition to the ethical considerations, Circular A–4 also identifies uncertainty in long-run interest rates as another reason why it is appropriate to use lower rates to discount intergenerational impacts, since recognizing such uncertainty causes the appropriate discount rate to decline gradually over progressively longer time horizons. The social costs of distant future climate damages—and by implication, the value of reducing them by lowering emissions of GHGs—are highly sensitive to the discount rate, and the present value of reducing future climate damages grows at an increasing rate as the discount rate used in the analysis declines. This ''non-linearity'' means that even if uncertainty about the exact value of the long-run interest rate is equally distributed between values above and below the 3 percent consumption rate of interest, the probability-weighted (or ''expected'') present value of a unit reduction in climate damages will be higher than the value calculated using a 3 percent discount rate. The effect of such uncertainty about the correct discount rate can be accounted for by using a lower ''certainty-equivalent'' rate to discount distant future damages, defined as the rate that produces the same expected present value of a reduction in future damages implied by the distribution of possible discount rates around what is believed to be the most likely single value.

For the final rule, NHTSA is updating its discount rates from the IWG recommendations to those found in the 2023 EPA SC–GHG Report. The EPA's discounting module represents an advancement on the work of the IWG in a number of ways. First, the EPA report uses the most recent evidence on the ''consumption rate of interest''—the rate at which we observe consumers trading off consumption today for consumption in the future. Second, EPA's approach incorporates the uncertainty in the consumption rate of interest over time, specifically by using certainty-equivalent discount factors which effectively reduce the discount rate progressively over time, so that the rate applied to near-term avoided climate damages will be higher than the rate applied to damages anticipated to occur further in the future. Finally, EPA's revised approach incorporates risk aversion into its modeling framework,, to recognize that individuals are likely to be willing to pay some additional amount to avoid the risk that the actual damages they experience might exceed their expected level. This gives some consideration to the insurance against low-probability but high-consequence climate damages that interventions to reduce GHG emissions offer. For more detail, see the 2023 EPA SC–GHG Report.[741]

When the streams of future emissions reductions being evaluated are moderate in terms of time (30 years or less), the EPA suggests to discount from the year of abatement to the present using the corresponding constant near-term target rates of 2.5, 2.0, and 1.5 percent. NHTSA's calendar year analysis includes fewer than 30 years of impacts (the calendar year captures emissions of all model years on the road through 2050), and the majority of emissions impacts considered in NHTSA's model year analysis also occur within this timeframe (vehicles in the MY analysis will continue to be on the road past 30 years, however nearly 97 percent of their lifetime emissions will occur during the first 30 years of their service given vehicles are used less as they age on average and a majority of the vehicles in this cohort will have already been retired completely from the fleet). Thus, NHTSA has elected to discount from the year of abatement back to the present value using constant near-term discount rates of 2.5, 2.0, and 1.5

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[736] National Academies of Sciences, Engineering, and Medicine. 2017. Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon Dioxide. Washington, DC: The National Academies Press. *https://nap.nationalacademies.org/catalog/24651/valuing-climate-damages-updating-estimation-of-the-social-cost-of* (Accessed: April 1, 2024).

[737] See page 3 of the 2023 EPA SC–GHG Report for more details on public notice and comment and peer review.

[738] 88 FR 56251 (Aug. 17, 2023).

[739] The Executive Office of the Present's Office of Management and Budget. 2003. Circular No. A–4. Regulatory Analysis. Available at: *https://www.whitehouse.gov/wp-content/uploads/legacy_drupal_files/omb/circulars/A4/a-4.pdf* (Accessed: Mar. 11, 2024).

[740] 2023 EPA SC–GHG Report, pp 62.

[741] See page 64 of 2023 EPA SC–GHG Report.

percent.[742] The 2023 EPA SC–GHG Report's central SC–GHG values are based on a 2 percent discount rate,[743] and for this reason NHTSA presents SC–GHG estimates discounted at 2 percent alongside its primary estimates of other costs and benefits wherever NHTSA does not report the full range of SC–GHG estimates. The agency's analysis showing our primary non-GHG impacts at 3 and 7 percent alongside climate-related benefits may be found in Chapter 8 of the FRIA for both LDVs and HDPUVs. We believe that this approach provides policymakers with a range of costs and benefits associated with the rule using a reasonable range of discounting approaches and associated climate benefits.

NHTSA has also produced sensitivity analyses that vary the SC–GHG values, as discussed in Section V.D, by applying the IWG SC–GHG values. NHTSA finds net benefits in each of these sensitivity cases. Accordingly, NHTSA's conclusion that this rule produces net benefits is consistent across a range of SC–GHG choices.

For additional details, see Chapter 6.2.1.2 of the TSD. For costs and benefits calculated with SC–GHG values and corresponding discount rates of 2.5 percent and 1.5 percent, see Chapter 9 of tIRIA.

(c) Comments and Responses About the Agency's Choice of Social Cost of Carbon Estimates and Discount Rates

A wide variety of comments were received regarding the social cost of greenhouse gas emissions. The first category pertains to the inclusion of a SC–GHG value in cost-benefit analysis calculations. Commenters including IPI and NRDC proposed that NHTSA incorporates the updated SC–GHG values from EPA's 2023 Report in the final rule.[744] Valero and others suggested that climate benefits, should they be included, be valued at discount rate above 7 percent.[745] Other commenters mention that research in this area is ongoing, has a degree of uncertainty regarding the choice of underlying parameters and models, and that a global consensus value has not been reached, therefore such a measure should not be incorporated in the analysis.[746]

Estimating the social costs of future climate damages caused by emissions of greenhouse gases, or SC–GHG, requires analysts to make a number of projections that necessarily involve uncertainty—for example, about the likely future pattern of global emissions of GHGs—and to model multifaceted scientific phenomena, including the effect of cumulative emissions and atmospheric concentrations of GHGs on climate measures including global surface temperatures and precipitation patterns. Each of these entail critical judgements about complex scientific and modeling questions. Doing so requires specialized technical expertise, accumulated experience, and expert judgment, and highly trained, experienced, and informed analysts can reasonably differ in their judgements. Further, in *CBD* v. *NHTSA,* the 9th Circuit concluded that uncertainty in SC–GHG estimates is not a reasonable excuse for excluding *any* estimate of the SC–GHG in the analysis of CAFE standards.[747]

Commenters raise questions about the specific assumptions and parameter values used to produce the estimates of the social costs of various GHGs that NHTSA relied upon in the proposed regulatory analysis and contend that using alternative assumptions and values would reduce the recommended values significantly. The agency notes EPA's analysis, like the IWG's, includes experts in climate science, estimation of climate-related damages, and economic valuation of those impacts, and that these individuals applied their collective expertise to review and evaluate available empirical evidence and alternative projections of important measures affecting the magnitude and cost of such damages. We believe that EPA's update, which builds on the IWG's work, represents the best current culmination in the field and has been vetted by both the public and experts in the field during the peer review. As such, we believe that EPA's estimates best represent the culminative impact of GHGs analyzed by this rule.[748]

DOT uses its own judgment in applying the estimates in this analysis. As a consequence, NHTSA views the chosen SC–GHG values as the most reliable among those that were available for it to use in its analysis. We feel that commenters did not address the inherent uncertainty in estimating the SC–GHG. Specifically, we note that any alternative model that attempts to project the costs of GHGs over the coming decades—and centuries—will be subject to the same uncertainty and criticisms raised by commenters.

A greater number of commenters mention the global scope involved in the calculation of the social cost of greenhouse gas emissions. Some contend that NHTSA should not consider any valuation which includes global benefits of reduced emissions, as the costs are incurred by manufacturers and consumers within the United States.[749] In contrast, the Center for Biological Diversity, Environmental Defense Fund, and others comment that,

> NHTSA appropriately focuses on a global estimate of climate benefits . . . While NHTSA offers persuasive justifications for this decision, many additional justifications further support this approach . . . The Energy Policy and Conservation Act (''EPCA''), National Environmental Policy Act, Administrative Procedure Act, and other key sources of law permit, if not require, NHTSA to consider the effects of U.S. pollution on foreign nations . . . Executive Order 13,990 instructs agencies to ''tak[e] global damages into account'' when assessing climate impacts because ''[d]oing so facilitates sound decision-making, recognizes the breadth of climate impacts, and support the international leadership of the United States on climate issues.[750]

NHTSA agrees that climate change is a global problem and that the global SC–GHG values are appropriate for this analysis. Emitting greenhouse gases creates a global externality, in that GHG emitted in one country mix uniformly with other gases in the atmosphere and the consequences of the resulting increased concentration of GHG are felt all over the world. The IWG concluded

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[742] As discussed in EPA SC–GHG Report, the error associated with using a constant discount rate rather than a certainty-equivalent rate path to calculate the present value of a future stream of monetized climate benefits is small for analyses with moderate time frames (*e.g.,* 30 years or less). The EPA SC–GHG Report also provides an illustration of the amount of climate benefits from reductions in future emissions that would be underestimated by using a constant discount rate relative to the more complicated certainty-equivalent rate path.

[743] *See* page 101 of the EPA SC–GHG Report (2023).

[744] CBD, EDF, IPI, Montana Environmental Information Center, Joint NGOs, Sierra Club, and Western Environmental Law Center, Docket No. NHTSA–2023–0022–60439, at 1.

[745] Valero, Docket No. NHTSA–2023–0022–58547, Attachment A, at 9.

[746] MEMA, Docket No. NHTSA–2023–0022–59204, Attachment A1, at 9; West Virginia Attorney General's Office, Docket No. NHTSA–2023–0022–63056, at 10; Landmark, Docket No. NHTSA–2023–0022–48725, at 3–5.

[747] *CBD* v. *NHTSA,* 538 F.3d 1172, 1197 (9th Cir. 2008).

[748] See page 3 of 2023 EPA SC–GHG Report for more details on public notice and comment and peer review.

[749] Valero, Docket No. NHTSA–2023–0022–58547, Attachment A, at 9; American Highway Users Alliance, Docket No. NHTSA–2023–0022–58180, at 8; The American Free Enterprise Chamber of Commerce, Docket No. NHTSA–2023–0022–62353, at 5; West Virginia Attorney General's Office, Docket No. NHTSA–2023–0022–63056, at 12; AmFree, Docket No. NHTSA–2023–0022–62353, at 5.

[750] CBD, EDF, IPI, Montana Environmental Information Center, Joint NGOs, and Western Environmental Law Center, Docket No. NHTSA–2023–0022–60439, at 3–6.

that a global analysis is essential for SC–GHG estimates because climate impacts directly and indirectly affect the welfare of U.S. citizens and residents through complex pathways that spill across national borders. These include direct effects on U.S. citizens and assets, investments located abroad, international trade, and tourism, and spillover pathways such as economic and political destabilization and global migration that can lead to adverse impacts on U.S. national security, public health, and humanitarian concerns. Those impacts are more fully captured within global measures of the social cost of greenhouse gases.

In addition, assessing the benefits of U.S. GHG mitigation activities requires consideration of how those actions may affect mitigation activities by other countries, as those international actions will provide a benefit to U.S. citizens and residents. A wide range of scientific and economic experts have emphasized the issue of reciprocity as support for considering global damages of GHG emissions. Using a global estimate of damages in U.S. analyses of regulatory actions allows the U.S. to continue to actively encourage other nations, including emerging major economies, to take significant steps to reduce emissions. The only way to achieve an efficient allocation of resources for emissions reduction on a global basis—and so benefit the U.S. and its citizens—is for all countries to base their policies on global estimates of damages.[751]

The SC–GHG values reported in EPA's 2023 Report provide a global measure of monetized damages from GHG reductions. EPA's report explains that ''The US economy is . . . inextricably linked to the rest of the world'' and that ''over 20% of American firms' profits are earned on activities outside of the country.'' On this basis EPA concludes ''Climate impacts that occur outside U.S. borders will impact the welfare of individuals and the profits of firms that reside in the US because of the connection to the global economy . . . through international markets, trade, tourism, and other activities.'' [752] Like the IWG, EPA also concluded that climate damages that originate in other nations can produce ''economic and political destabilization, and global migration that can lead to adverse impacts on U.S. national security, public health, and humanitarian concerns.'' NHTSA is aligned with EPA that climate damages to the rest of the world will result in damages that will be felt domestically, and thus concludes that SC–GHG values that incorporate both domestic and international damages are appropriate for its analyses.

While global estimates of the SC–GHG are the most appropriate values to use for the above stated reasons, new modeling efforts suggest that U.S.-specific damages are very likely higher than previously estimated. For instance, the EPA's Framework for Evaluating Damages and Impacts (FrEDI) is a ''reduced complexity model that projects impacts of climate change within the United States through the 21st century'' that offers insights on some omitted impacts that are not yet captured in global models.[753] Results from FrEDI suggest that damages due to climate change within the contiguous United States are expected to be substantial. EPA's recent tailpipe emissions standards cite a FrEDI-produced partial SC–CO$_2$ estimate of $41 per metric ton.[754] This U.S.-specific value is comparable to SC–CO$_2$ estimates NHTSA has used for prior rulemakings and used in sensitivity analyses for this rulemaking.[755] NHTSA notes both that the FrEDI estimates do not include many climate impacts and thus are underestimates of harm, and that the FrEDI estimates include impact categories that are not available for the rest of the world. and thus, are missing from the global estimates used here. The damage models applied to generate EPA's estimates of the global SC–CO$_2$ estimates used in this final rule (the Data-driven Spatial Climate Impact Model (DSCIM) and the Greenhouse Gas Impact Value Estimator (GIVE)), which as noted do not reflect many important climate impacts, provide estimates of climate change impacts physically occurring within the United States of $16-$18 per metric ton for 2030 emissions. EPA notes that ''[w]hile the FrEDI results help to illustrate how monetized damages physically occurring within the [continental US] increase as more impacts are reflected in the modeling framework, they are still subject to many of the same limitations associated with the DSCIM and GIVE damaIules, including the omission or partial modeling of important damage categories.'' [756] EPA also notes that the DSCIM and GIVE estimates of climate change impacts physically occurring within the United States are, like FrEDI, ''not equivalent to an estimate of the benefits of marginal GHG mitigation accruing to U.S. citizens and residents'' in part because they ''exclude the myriad of pathways through which global climate impacts directly and indirectly affect the interests of U.S. citizens and residents.'' [757]

Taken together, applying the U.S.-specific partial SC–GHG estimates derived from the multiple lines of evidence described above to the GHG emissions reduction expected under the final rule would yield substantial benefits. For example, the present value of the climate benefits as measured by FrEDI (under a 2 percent near-term Ramsey discount rate) from climate change impacts in the contiguous United States for the preferred alternative for passenger cars and light trucks (CY perspective), for passenger cars and light trucks (MY perspective), and for HDPUVs, are estimated to be $19.6 billion, $4.7 billion, and $1.5 billion, respectively.[758] However, the numerous explicitly omitted damage categories and other modeling limitations discussed above and throughout the EPA's 2023 Report make it likely that these estimates significantly underestimate the benefits to U.S. citizens and residents of the GHG reductions from the final rule; the limitations in developing a U.S.-specific

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[751] For more information about the appropriateness of using global estimates of SC–GHGs, which NHTSA endorses, see discussion beginning on pg 3–20 of U.S. Environmental Protection Agency. Regulatory Impact Analysis of the Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review. EPA–452/R–23–013, Office of Air Quality Planning and Standards, Health and Environmental Impacts Division, Research Triangle Park, NC, December 2023 (hereinafter, ''2023 EPA Oil and Gas Rule RIA'').

[752] *See* Section 1.3, 2023 EPA SC–GHG Report.

[753] EPA. 2021. Technical Documentation on the Framework for Evaluating Damages and Impacts (FrEDI). U.S. Environmental Protection Agency, EPA 430–R–21–004. Summary information at *https://www.epa.gov/cira/fredi.* Accessed 5/22/2024.

[754] *See* 9–16 of U.S. Environmental Protection Agency. *Multi-Pollutant Emissions Standards for Model Years 2027 and Later Light-Duty and Medium-Duty Vehicles Regulatory Impact Analysis.* EPA–420–R–24–004, Assessment and Standards Division, Office of Transportation and Air Quality, March 2024.

[755] For instance, NHTSA's previous final rule used a global SC–CO$_2$ value of $50 in calendar year 2020. *See* Section 6.2 of National Highway Traffic Safety Administration. *Technical Support Document: Final Rulemaking for Model Years 2024–2026 Light-Duty Vehicle Corporate Average Fuel Economy Standards.* March 2022.

[756] *See* p. 9–16 of U.S. Environmental Protection Agency. *Multi-Pollutant Emissions Standards for Model Years 2027 and Later Light-Duty and Medium-Duty Vehicles Regulatory Impact Analysis.* EPA–420–R–24–004, Assessment and Standards Division, Office of Transportation and Air Quality, March 2024.

[757] 2023 EPA SC–GHG Report.

[758] DCIM and GIVE use global damage functions. Damage functions based on only U.S.-data and research, but not for other parts of the world, were not included in those models. FrEDI does make use of some of this U.S.-specific data and research and as a result has a broader coverage of climate impact categories.

estimate that accurately captures direct and spillover effects on U.S. citizens and residents further demonstrates that it is more appropriate to use a global measure of climate benefits from GHG reductions.

Finally, the last major category of comments pertained to the choice of discount rate applied to climate-related benefits and costs. Valero contends that the appropriate choice of discount rate in this case is an unsettled issue and that if global climate benefits are considered, a global discount rate above 8 percent should be used.[759] Our Children's Trust commented that NHTSA should consider intergenerational equity and calculate climate benefits using negative, zero, or near-zero percent discount rates.[760] Several commenters, including CBD and IPI,[761] [762] support the usage of the discount rates included in the EPA's SC–GHG update, mention that Executive Order 13990 instructs agencies to ensure that the social cost of greenhouse gas values adequately account for intergenerational equity, and argue that a capital-based discount rate is inappropriate for these multigenerational climate effects.

As previously noted, NHTSA presents and considers a range of discount rates for climate-related benefits and costs, including 2.5, 2.0, and 1.5 percent. Contrary to the position put forward by Children's Trust that it is unlawful to discount the estimated costs of SC–GHG, we also believe that discounting the stream of climate benefits from reduced emissions from the rule in order to develop a present value of the benefits of reducing GHG emissions is consistent with the law, and that the discounting approach used by the EPA is reasonable. Courts have previously reviewed and affirmed rules that discount climate-related costs.[763] Courts have likewise advised agencies to approach cost-benefit analyses with impartiality, to ensure that important factors are captured in the analysis, including climate benefits,[764] and to ensure that the decision rests ''on a consideration of the relevant factors.'' [765] NHTSA has followed these principles here. In addition, NHTSA believes that discount rates at or above the opportunity cost of capital (7 percent) are inappropriate to use for GHG emissions that have intergenerational impacts. As discussed at length above, the consumption rate of interest is a more appropriate choice as it is the rate at which we observe consumers trading off consumption today for consumption in the future. Circular A–4 also identifies uncertainty in long-run interest rates as another reason why it is appropriate to use lower rates to discount intergenerational impacts, since recognizing such uncertainty causes the appropriate discount rate to decline gradually over progressively longer time horizons. In addition, the approach used incorporates rIrsion into its the modeling framework, which recognizes that individuals are likely willing to pay some additional amount to avoid the risk that the actual damages they experience might exceed their expected level. This gives some consideration to the insurance against low-probability but high-consequence climate damages that interventions to reduce GHG emissions offer.[766] The impacts on future generations, uncertainty, and risk aversion are reflected in the estimates used in this analysis. The 2023 EPA SC–GHG Report's central SC–GHG values are based on a 2 percent discount rate,[767] and for this reason NHTSA presents in its analysis of this Final Rule SC–GHG estimates discounted at 2 percent together with its primary estimates of other costs and benefits wherever NHTSA does not report the full range of SC–GHG estimates. For additional details regarding the choice of discount rates for climate related benefits, see Chapter 6.2.1.2 of the TSD.

(2) Reduced Health Damages

The CAFE Model estimates monetized health effects associated with emissions from directly emitted particulate matter 2.5 microns or less in diameter ($PM_{2.5}$) and two precursors to $PM_{2.5}$ (NO_X and SO_2). As discussed in Section III.F above, although other criteria pollutants are currently regulated, only impacts from these three pollutants are calculated since they are known to be emitted regularly from mobile sources, have the most adverse effects on human health, and have been the subject of extensive research by EPA to estimate the benefits of reducing these pollutants. The CAFE Model computes the monetized $PM_{2.5}$-related health damages from each of the three pollutants by multiplying the monetized health impact per ton by the total tons of each pollutant emitted, including from both upstream and downstream sources. Reductions in these costs from their level under the reference baseline alternative that are projected to result from adopting alternative standards are treated as external benefits of those alternatives. Chapter 5 of the TSD accompanying this final rule includes a detailed description of the emission factors that inform the CAFE Model's calculation of the total tons of each pollutant associated with upstream and downstream emissions.

These monetized health benefit per ton values are closely related to the health incidence per ton values described above in Section III.F and in detail in Chapter 5.4 of the TSD. We use the same EPA sources that provided health incidence values to determine which monetized health impacts per ton values to use as inputs in the CAFE Model. Like the estimates associated with health incidences per ton of criteria pollutant emissions, we used an EPA TSD, multiple papers written by EPA staff and conversations with EPA staff to appropriately account for monetized damages for each pollutant associated with the source sectors included in the CAFE Model. The various emission source sectors included in the EPA papers do not always correspond exactly to the emission source categories used in the CAFE Model. In those cases, we mapped multiple EPA sectors to a single source category and computed a weighted average of the health impact per ton values.

The EPA uses the value of a statistical life (VSL) to estimate premature mortality impacts, and a combination of willingness to pay estimates and costs of treating the health impact for estimating the morbidity impacts. EPA's 2018 technical support document, ''Estimating the Benefit per Ton of Reducing $PM_{2.5}$ Precursors from 17 Sectors,'' (referred to here as the 2018 EPA source apportionment TSD) contains a more detailed account of how health incidences are monetized. It is important to note that the EPA sources cited frequently refer to these monetized health impacts per ton as ''benefits per ton,'' since they describe these estimates in terms of emissions avoided. In the CAFE Model input structure, these are

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[759] Valero, Docket No. NHTSA–2023–0022–58547, Attachment A, at 9.

[760] OCT, Docket No. NHTSA–2023–0022–51242, at 3.

[761] CBD, EDF, IPI, Montana Environmental Information Center, Joint NGOs, Sierra Club, and Western Environmental Law Center, Docket No. NHTSA–2023–0022–60439, at 17–22.

[762] IPI, Docket No. NHTSA–2023–0022–60485, at 17–20.

[763] *See, e.g., E.P.A.* v. *EME Homer City Generation,* L.P., 572 U.S. 489 (2015).

[764] *CBD* v. *NHTSA,* 538 F.3d 1172, 1197 (9th Cir. 2008).

[765] State Farm, 463 U.S. 29, 43 (1983) (internal quotation marks omitted).

[766] In addition to the extensive discussion found in the 2023 EPA SC–GHG Report, a brief summary of the merits of the revised discounting approach may be found on pages 3–14 and 3–15 of 2023 EPA Oil and Gas Rule RIA.

[767] See page 101 of the EPA SC–GHG Report (2023).

generally referred to as monetized health impacts or damage costs associated with pollutants emitted (rather than avoided), unless the context states otherwise.

The CAFE Model health impacts inputs are based partially on the structure of the 2018 EPA source apportionment TSD, which reported benefits per ton values for the years 2020, 2025, and 2030. For the years in between the source years used in the input structure, the CAFE Model applies values from the closest source year. For example, the model applies 2020 monetized health impact per ton values for calendar years 2020–2022 and applies 2025 values for calendar years 2023–2027. In order for some of the monetized health damage values to match the structure of other impacts costs, DOT staff developed proxies for 7% discounted values for specific source sectors by using the ratio between a comparable sector's 3% and 7% discounted values. In addition, we used implicit price deflators from the Bureau of Economic Analysis (BEA) to convert different monetized estimates to 2021 dollars, in order to be consistent with the rest of the CAFE Model inputs.

This process is described in more detail in Chapter 6.2.2 of the TSD accompanying this final rule. In addition, the CAFE Model documentation contains more details of the model's computation of monetized health impacts. All resulting emission damage costs for $PM_{2.5}$-related pollutants are located in the Criteria Emissions Cost worksheet of the Parameters file. The States and Cities commented that NHTSA should emphasize that although only NO_X, SO_X, and $PM_{2.5}$ reductions are monetized (in terms of their contribution to ambient $PM_{2.5}$ formation), total benefits of reduced pollution are larger although they do not appear in the benefit-cost-analysis. NHTSA agrees, and notes that although we do not have a basis for valuing other pollutants, we acknowledge that they form part of the unquantified benefits that likely arise from this rule.

One specific category of benefits that is not monetized in our analysis is the health harms of air toxics and ozone. ALA brought forward the absence of the health harms of air toxics in their comments on the NPRM, stating that the missing health harms of air toxics are a limit of the health impacts analysis.[768] Historically, these pollutants have not typically been monetized, and as such we currently have no basis for that valuation. In the case of ozone, monetized BPT values that exist in the literature do not correspond to the source sectors we need for our analysis (namely NHTSA notes that these benefits are important although they have not been quantified.

(3) Reduction in Petroleum Market Externalities

The standards would decrease domestic consumption of gasoline, producing a corresponding decrease in the Nation's demand for crude petroleum, a commodity that is traded actively in a worldwide market. Because the U.S. accounts for a significant share of global oil consumption, the resulting decrease in global petroleum demand will exert some downward pressure on worldwide prices.

U.S. consumption and imports of petroleum products have three potential effects on the domestic economy that are often referred to collectively as ''energy security externalities,'' and increases in their magnitude are sometimes cited as possible social costs of increased U.S. demand for petroleum. Symmetrically, reducing U.S. petroleum consumption and imports can reduce these costs, and by doing so provide additional external benefits from establishing higher CAFE and fuel efficiency standards.

First, any increase in global petroleum prices that results from higher U.S. gasoline demand will cause a transfer of revenue to oil producers worldwide from consumers of petroleum, because consumers throughout the world are ultimately subject to the higher global price that results. Under competitive market assumptions, this transfer is simply a shift of resources that produces no change in global economic output or welfare. Since the financial drain it produces on the U.S. economy may not be considered by individual consumers of petroleum products, it is sometimes cited as an external cost of increased U.S. petroleum consumption.

As the U.S. has transitioned towards self-sufficiency in petroleum production (the nation became a net exporter of petroleum in 2020), this transfer is increasingly from U.S. consumers of refined petroleum products to U.S. petroleum producers, so it not only leaves welfare unaffected but even ceases to be a financial burden on the U.S. economy. In fact, to the extent that the U.S. becomes a larger net petroleum exporter, any transfer from global consumers to petroleum producers becomes a financial benefit to the U.S. economy. Nevertheless, uncertainty in the nation's long-term import-export balance makes it difficult to project precisely how these effects might change in response to increased consumption.

The loss of potential GDP from this externality will depend on the degree that global petroleum suppliers like the Organization of Petroleum Exporting Countries (OPEC) and Russia exercise market power which raise oil market prices above competitive market levels. In that situation, increases in U.S. gasoline demand will drive petroleum prices further above competitive levels, thus exacerbating this deadweight loss. More stringent standards lower gasoline demand and hence reduce these losses.

Over most of the period spanned by NHTSA's analysis, any decrease in domestic spending for petroleum caused by the effect of lower U.S. fuel consumption and petroleum demand on world oil prices is expected to remain entirely a transfer within the U.S. economy. In the case in which large producers are able to exercise market power to keep global prices for petroleum above competitive levels, this reduction in price should also increase potential GDP in the U.S. However, the degree to which OPEC and other producers like Russia are able to act as a cartel depends on a variety of economic and political factors and has varied widely over recent history, so there is significant uncertainty over how this will evolve over the horizon that NHTSA models. For these reasons, lower U.S. spending on petroleum products that results from raising standards, reducing U.S. gasoline demand, and the downward pressure it places on global petroleum prices is not included among the economic benefits accounted for in the agency's evaluation of this final rule.

Second, higher U.S. petroleum consumption can also increase domestic consumers' exposure to oil price shocks and thus increase potential costs to all U.S. petroleum users from possible interruptions in the global supply of petroleum or rapid increases in global oil prices. Because users of petroleum products are unlikely to consider the effect of their increased purchases on these risks, their economic value is often cited as an external cost of increased U.S. consumption. Decreased consumption, which we expect as a result of the standards, decreases this cost. We include an estimate of this impact of the standards, and an explanation of our methodology can be found in Chapter 6.2.4.4 of the TSD.

Finally, some analysts argue that domestic demand for imported petroleum may also influence U.S. military spending; because the increased cost of military activities

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[768] ALA, Docket No. NHTSA–2023–0022–60091, at 2.

would not be reflected in the price paid at the gas pump, this is often suggested as a third category of external costs from increased U.S. petroleum consumption. For example, NHTSA has received extensive comments to past rulemakings about exactly this effect on its past actions from the group Securing America's Energy Future. Most recent studies of military-related costs to protect U.S. oil imports conclude that significant savings in military spending are unlikely to result from incremental reductions in U.S. consumption of petroleum products on the scale that would result from adopting higher standards. While the cumulative effects of increasing fuel economy over the long-term likely have reduced the amount the U.S. has to spend to protect its interest in energy sources globally—avoid being beholden to geo-political forces that could disrupt oil supplies—it is extremely difficult to quantify the impacts and even further to identify how much a single fuel economy rule contributes. As such NHTSA does not estimate the impact of the standards on military spending. See Chapter 6.2.4.5 of the TSD for additional details.

Each of these three factors would be expected to decrease incrementally as a consequence of a decrease in U.S. petroleum consumption resulting from the standards. Chapter 6.2.4 of the TSD provides a comprehensive explanation of NHTSA's analysis of these three impacts.

NHTSA sought comment on its accounting of energy security in the proposal. The Institute for Energy Research and AFPM both noted that the United States is now a net-exporter of crude oil, and that a significant share of imported crude oil is sourced from other North American countries.[769] The American Enterprise Institute suggested that the macroeconomic risks associated with oil supply shocks like those described by NHTSA in its proposal are reflected in the price of oil since it is a globally traded commodity.[770] As a result, they argue that since all countries face common international prices for these products (outside of transportation costs and other second order differences), the energy security of countries does not depend on its overall level of imports. Several commenters also argued that increasing reliance on domestically produced ethanol rather than battery electric vehicles represents a superior method for improving energy security.[771]

NHTSA noted in its proposal the importance of the United States' role as a net exporter in its quantification of energy security related benefits. For example, NHTSA discussed the so-called ''monopsony effect'' or the effect of reduced consumption on global oil prices. NHTSA noted that this represents a transfer between oil producers and consumers, rather than a real change in domestic welfare, and since the United States is no longer a net importer the monopsony effect on global prices no longer represents a transfer from producers in other countries. However, NHTSA disagrees with the suggestion that this status eliminates the energy security externalities that NHTSA quantified in its analysis. As described in TSD Chapter 6, NHTSA considered the effect of reductions in domestic consumption on the expected value of U.S. macroeconomic losses due to foreign oil supply shocks in future years. The expected magnitude of the effect of these shocks on overall domestic economic activity is determined by the probability of these shocks, the overall exposure of the global oil supply to these shocks, (which depends upon the size of U.S. gross oil imports), the short run elasticities of supply and demand for oil, and the sensitivity of the U.S. economy to changes in oil prices.

NHTSA analyzed these drivers of energy security costs in its proposal and concluded that there were still strong reasons to believe that changes in fuel economy standards could produce economic benefits by reducing them. As can be seen through the events NHTSA listed in its discussion of energy security in Chapter 6 of the TSD, foreign oil shocks like the one caused by Russia's invasion of Ukraine remain a risk that can at least in the short-term influence global oil supply and prices, which adversely affect consumers and disrupt economic growth, although no recent example of oil supply shocks has reached the magnitude of the OPEC oil embargo or Iranian Revolution during the 1970s. NHTSA will continue to monitor the literature for updated estimates of the probability and size foreign oil shocks and update its estimates accordingly. As noted in the TSD, the U.S. has in recent years become a net exporter of oil. However, the U.S. still only accounts for about 14.7 percent of global oil production, and the U.S., Canada, and Mexico together account for less than a quarter of global oil production according to the U.S. EIA.[772] By contrast, seven countries in the Persian Gulf region account for about one-third of production and held about half of the world's proven reserves. Russia alone accounted for 12.7 percent of production in 2022, and the global supply shock caused by Russia's invasion of Ukraine was followed by a surge of more than 20 percent in crude oil prices.[773] Clearly substantial shares of the global oil supply remain in regions that have proven vulnerable to the exact supply shocks described by NHTSA in its rulemaking documents. Furthermore, the U.S., while on balance a net-exporter, continues to import substantial quantities of oil from countries at risk of shocks. In 2022, Iraq, Saudi Arabia, and Colombia accounted for 14 percent of oil imports in the U.S., or about 1.1 million barrels per day.[774] On net, the U.S. still imports just under 3 million barrels of crude oil per day.[775] Due to refinery configurations, many refiners in the U.S., especially in the Midwest and Gulf Coast still most profitably refine heavy, sour crude oil from abroad. Indeed, in its 2023 AEO the EIA still projects that the U.S. will import 6.65 million barrels per day of oil in 2050.[776] Moreover, U.S. consumers are also exposed to foreign oil shocks through other imported goods that use petroleum as an input. Thus, NHTSA still believes that it is correct to assume that changes in domestic consumption are likely to affect demand for foreign oil.

NHTSA also disagrees with the conclusion that these energy security risks are efficiently priced by global markets. Traded oil prices represent equilibrium outcomes determined by

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[769] Institue for Energy Research, Docket No. NHTSA–2023–0022–63063, at 3; AFPM, Docket No. NHTSA–2023–0022–61911, at 22.

[770] AEI, Docket No. NHTSA–2023–0022–54786, at 22–24.

[771] CFDC et al., Docket No. NHTSA–2023–0022–62242, at 22–23; Institute for Energy Research, Docket No. NHTSA–2023–0022–63063, at 3–4.

[772] U.S. Energy Information Agency, International Energy Statistics, Crude oil production including lease condensate, as of September 6, 2023. Available at: *https://www.eia.gov/energyexplained/oil-and-petroleum-products/where-our-oil-comes-from.php.* (Accessed: March 25, 2024).

[773] WTI spot prices rose from $93/barrel the week of February 18, 2022, the week before Russia's invasion of Ukraine. The price rose to $113/barrel the week of March 11, 2022, and eventually reached a high of around $120/barrel in June 2022. Data available at: *https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=RWTC&f=W,* (Accessed: April 29, 2024).

[774] U.S. Energy Information Agency, ''Oil and petroleum products explained: Oil imports and exports'', Available at: *https://www.eia.gov/energyexplained/oil-and-petroleum-products/imports-and-exports.php,* (Accessed: April 29, 2024).

[775] *Id.*

[776] U.S. Energy Information Agency, *Annual Energy Outlook 2023,* Table 11. Petroleum and Other Liquids Supply and Disposition, Available at: *https://www.eia.gov/outlooks/aeo/data/browser/#/?id=11-AEO2023&cases=ref2023&sourcekey=0,* (Accessed: March 25, 2024).

global supply and demand for oil. Global demand is determined by the aggregation of global consumers' willingness to pay for oil and the products it produces. This willingness to pay depends on the private benefits derived from oil products. The macroeconomic disruption costs described by NHTSA are borne across the economy, meaning that they are unlikely to be considered by individual consumers in their decision-making calculus. For this reason, economists have classified them as externalities, and thus a potential source of socially inefficient outcomes.[777] The magnitude of these macroeconomic disruptions from oil supply shocks depends directly on the overall oil intensity of the economy. A more fuel-efficient fleet of vehicles is expected to lower the economy's oil intensity. Furthermore, EPCA, the statute that confers the agency with the authority to set standards, was enacted with the stated purpose to increase energy independence and security, and set out to accomplish these goals through increasing the efficiency of energy consuming goods such as automobiles.[778] Congress explicitly directed the agency to consider the need of the United States to conserve energy when setting maximum feasible standards.[779] The suggestion that NHTSA should forgo the potential impacts to energy security of setting standards cuts against the very fabric of public policy underlying EPCA.

NHTSA is also monitoring the availability of critical minerals used in electrified powertrains and whether any shortage of such materials could emerge as an additional energy security concern. While nearly all electricity in the United States is generated through the conversion of domestic energy sources and thus its supply does not raise security concerns, EVs also require batteries to store and deliver that electricity. Currently, the most commonly used electric vehicle battery chemistries include relatively scarce materials (compared to other automotive parts) which are sourced, in part, from potentially insecure or unstable overseas sites and like all mined materials (including those in internal combustion engine vehicles) can pose environmental challenges during extraction and conversion to usable material. Known supplies of some of these critical minerals are also highly concentrated in a few countries and therefore face similar market power concerns to petroleum products.

NHTSA is restricted from considering the fuel economy of alternative fuel sources in determining CAFE standards, and as such, the CAFE Model restricts the application of BEV pathways and PHEV electric efficiency in simulating compliance with fuel economy regulatory alternatives. While the cost of critical minerals may affect the cost to supply both plug-in and non-plug-in hybrids that require larger batteries, this would apply primarily to manufacturers whose voluntary compliance strategy includes electrification given the greater mineral requirements of battery electric vehicles and plug-in hybrid-electric vehicles compared with non-plug-in hybrids. NHTSA did not include costs or benefits related to these emerging energy security considerations in its analysis for its proposal and sought comment on whether it is appropriate to include an estimate in the analysis and, if so, which data sources and methodologies it should employ.

NHTSA received a number of comments suggesting that it should include costs and benefits related to these emerging energy security considerations. Several commenters noted that politically unstable countries or countries with which the U.S. does not have friendly trade relations, including China, mine or process a significant share of the minerals used in battery production, including lithium, cobalt, graphite and nickel.[780] AFPM also argued that the penetration rate of BEVs in NHTSA's No-Action alternative would require supply chain improvements that they contend are highly uncertain to occur, or that the battery chemistry technologies necessary to alleviate these concerns were not likely to be available in the timeframe suggested by NHTSA's analysis.[781] Some of these commenters suggested that mineral security should be included in NHTSA's analysis as a cost associated with adoption of technologies that require these minerals, and that the failure to include this as a cost was arbitrary and capricious.[782] ZETA on the other hand suggested that the demands for critical minerals could be met through reserves in friendly countries, and noted the steps taken by both the public and private sector to expand domestic critical mineral production.[783] The National Association of Manufacturers and the U.S. Chamber of Commerce both suggested that expanding domestic supply of critical minerals required the Administration and Congress to expedite permitting.[784]

NHTSA agrees with commenters that the increase in battery demand likely will require significant expansion of production of certain critical minerals, although critical minerals have long been a component of vehicles and many other goods consumed in the United States. NHTSA also notes the concerted efforts across the federal government to shift supply chains to ensure that a larger share of critical mineral production comes from politically stable sources. Between the publication of NHTSA's proposal and the final rule, ANL produced a study of the prospective supply of upstream critical materials used to meet the U.S.'s EV and Energy Storage System deployment targets for 2035.[785] According to ANL, the U.S. is positioned to meet lithium demand through a combination of domestic production as well as imports from FTA countries.[786] The U.S. will need to source graphite, nickel, and cobalt from partner countries (including those with and without FTAs) in the near and medium term.[787] Thus, NHTSA believes that there is strong evidence that the U.S. has significant opportunities to diversify supply chains away from current suppliers like China.

Further, NHTSA notes that considering mineral security in its analysis of incremental societal costs and benefits would be unlikely to materially impact the ranking of its regulatory alternatives. EPCA constrains NHTSA from considering BEV adoption as a compliance strategy during standard setting years in its light duty analysis. As a result, there will be

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[777] See Brown, S.P., New estimates of the security costs of U.S. oil consumption, *Energy Policy,* 113, (2018) page 172.

[778] Public Law 110–140.

[779] 42 U.S.C. 32902(f).

[780] American Consumer Institute, Docket No. NHTSA–2023–0022–50765, at 6–7; AHUA, Docket No. NHTSA–2023–0022–58180, at 7; U.S. Chamber of Commerce, Docket No. NHTSA–2023–0022–61069, at 5; West Virginia Attorney General's Office, Docket No. NHTSA–2023–0022–63056, at 14; CFDC et al., Docket No. NHTSA–2023–0022–62242, at 22–23; Institute for Energy Research, Docket No. NHTSA–2023–0022–63063, at 3.

[781] AFPM, Docket No. NHTSA–2023–0022–61911, at 13–14.

[782] AFPM, Docket No. NHTSA–2023–0022–61911, at 19; West Virginia Attorney General's Office, Docket No. NHTSA–2023–0022–63056, at 14–15.

[783] ZETA, Docket No. NHTSA–2023–0022–60508, at 29–46.

[784] National Association of Manufacturers, Docket No. NHTSA–2023–0022–59289, at 3; U.S. Chamber of Commerce, Docket No. NHTSA–2023–0022–61069, at 5.

[785] Barlock, Tsisilile A. et al., ''Securing Critical Minerals for the U.S. Electric Vehicle Industry'', Argonne National Laboratory, Nuclear Technologies and National Security Directorate, ANL–24/06, Feb. 2024, Available at: *https://publications.anl.gov/anlpubs/2024/03/187907.pdf.* (Accessed: April 5, 2024).

[786] *Id.* at viii.

[787] *Id.* at viii.

minimal incremental demand for batteries and critical minerals in regulatory alternatives, and thus minimal incremental societal costs related to mineral security. While BEV adoption—including compliance with ZEV regulatory programs—is considered in the No-Action Alternative, mineral security costs associated with the adoption of BEVs in these cases are (1) not incremental costs associated with changes in CAFE standards, and (2) not considered by consumers and manufacturers outside of how they impact technology costs and vehicle prices, both of which are considered in NHTSA's analysis. In the HDPUV fleet, a similar pattern emerges even in the absence of similar constraints; the overwhelming majority of electrification takes place in the reference baseline. Further, given the relatively small volume of HDPUVs, the incremental demand for any critical minerals is minimal compared to the total global supply.

Finally, NHTSA notes that while commenters suggested that NHTSA include mineral security in its analysis, they did not recommend a specific methodology for how to do so. During its analysis NHTSA surveyed the economics literature and did not find a comparable existing set of methods for analyzing mineral security as it did for petroleum market externalities. This is largely due to the relatively recent emergence of this topic. Several of the inputs used in NHTSA's energy security analysis (distributions of estimates of its elasticity parameters, supply shock probability distributions, long term projections of supply and demand for petroleum) rely on decades of research which do not exist for the emerging topic of mineral security. NHTSA is continuing to monitor research in this field and is considering implementing estimates of these costs in future rulemakings but did not include them in this final rule.

(4) Changes in Labor Use and Employment

As vehicle prices rise, we expect consumers to purchase fewer vehicles than they would have at lower prices. If manufacturers produce fewer vehicles as a consequence of lower demand, they may need less labor to produce and assemble vehicles, while dealers may need less labor to sell the vehicles. Conversely, as manufacturers add equipment to each new vehicle, the industry will require labor resources to develop, sell, and produce additional fuel-saving technologies. We also account for the possibility that new standards could shift the relative shares of passenger cars and light trucks in the overall fleet. Since the production of different vehicles involves different amounts of labor, this shift affects the required quantity of labor.

The analysis considers the direct labor effects that the standards have across the automotive sector. The effects include (1) dealership labor related to new light-duty and HDPUV unit sales; (2) assembly labor for vehicles, engines, and transmissions related to new vehicle unit sales; and (3) labor related to mandated additional fuel savings technologies, accounting for new vehicle unit sales. NHTSA has now used this methodology across several rulemakings but has generally not emphasized its results, largely because NHTSA found that attempting to quantify the overall labor or economic effects was too uncertain and difficult. We have also excluded any analysis of how changes in direct labor requirements could change employment in adjacent industries.

NHTSA still believes that such an expanded analysis may be outside the effects that are reasonably traceable to the final rule; however, NHTSA has identified an exogenous model that can capture both the labor impacts contained in the CAFE Model and the secondary macroeconomic impacts due to changes in sales, vehicle prices, and fuel savings. Accompanying this final rule is a docket memo explaining how the CAFE Model's outputs may be used within Regional Economic Models, Inc. (REMI)'s PI + employment model to quantify the impacts of this final rule. We received comment from the Joint NGOs regarding the proposal for additional analysis in the docket memo stating that NHTSA should not include this additional analysis since the public was not given the opportunity to comment on results.[788] Although we were unable to fully implement the side analysis with finalized results for this rule, we are continuing to explore the possibility of including these impacts in future analyses.

The United Auto Workers (UAW) commented that NHTSA should perform additional analysis of the impacts of the standards on employment, with a particular focus on union jobs and new EV jobs.[789] Although we do not currently look at labor impacts by specific technologies, we may consider including it in future analyses. All labor effects are estimated and reported at a national aggregate level, in person-years, assuming 2,000 hours of labor per person-year. These labor hours are not converted to monetized values because we assume that the labor costs are included into a new vehicle's purchasing price. The analysis estimates labor effects from the forecasted CAFE Model technology costs and from review of automotive labor for the MY 2022 fleet. NHTSA uses information about the locations of vehicle assembly, engine assembly, and transmission assembly, and the percent of U.S. content of vehicles collected from American Automotive Labeling Act (AALA) submissions for each vehicle in the reference fleet. The analysis assumes that the fractions of parts that are currently made in the U.S. will remain constant for each vehicle as manufacturers add fuel-savings technologies. This should not be construed as a prediction that the percentage of U.S.-made parts—and by extension U.S. labor— will remain constant, but rather as an acknowledgement that NHTSA does not have a clear basis to project where future production may shift. The analysis also uses data from the NADA annual report to derive dealership labor estimates.

While the IRA tax credit eligibility is *not* dependent on our labor assumptions here, if NHTSA were able to dynamically model changes in parts content with enough confidence in its precision, NHTSA could potentially employ those results to dynamically model a portion of tax credit eligibility.

Some commenters argued that culmination of the standards and the further adoption of BEVs would significantly impair the automotive industry through dramatically reduced sales, leading to a substantial number of layoffs, and accused the agency of improperly ignoring this unintended consequence.[790] The agency disagrees. First, the agency notes that the premise in these comments is unsupported. As noted in sales, we believe that sales are largely determined by exogenous market factors, and our standards will have a marginal impact. Second, electrification is not a compliance pathway for CAFE, so any impacts would be contained to the reference baseline fleet through standard setting years. Finally, commenters did not provide any evidence that BEV adoption would harm domestic jobs and sales and relied solely on speculation.

In sum, the analysis shows that the increased labor from producing additional technology necessary to meet

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[788] Joint NGOs, Docket No. NHTSA–2023–0022–61944–A2, at 66.

[789] UAW, Docket No. NHTSA–2023–0022–63061–A1, at 2–3.

[790] Heritage Foundation-Mario Loyola, Docket No. NHTSA–2023–0022–61952, at 7–8.

the preferred alternative will outweigh any decreases attributable to the change in new vehicle sales. For a full description of the process NHTSA uses to estimate labor impacts, see Chapter 6.2.5 of the TSD.

3. Costs and Benefits Not Quantified

In addition to the costs and benefits described above, Table III–7 includes two-line items without values. The first is maintenance and repair costs. Many of the technologies manufacturers apply to vehicles to meet the standards are sophisticated and costly. The technology costs capture only the initial or ''upfront'' costs to incorporate this equipment into new vehicles; however, if the equipment is costlier to maintain or repair—as seems likely for at least more conventional technology because the materials used to produce the equipment are more expensive and the equipment itself is significantly more complex and requires more time and labor to maintain or repair—, then consumers will also experience increased costs throughout the lifetime of the vehicle to keep it operational. Conversely, electrification technologies offer the potential to lower repair and maintenance costs. For example, BEVs do not have engines that are costly to maintain, and all electric pathways with regenerative braking may reduce the strain on braking equipment and consequentially extend the useful life of braking equipment. We received several comments concerned with electric vehicle battery replacement costs and maintenance/repair cost differences between EVs and ICEs. The Heritage Foundation and the American Consumer Institute noted that EV battery replacement costs are expensive, and AFPM commented that these battery replacement costs will impact lower-income households.[791]

The West Virginia Attorney General's Office commented that NHTSA should include a life-cycle analysis, emphasizing that EVs' complicated powertrains could lead to higher maintenance and repair costs.[792] We do not currently include a life-cycle analysis as part of the CAFE Model but may consider incorporating some aspects of this into future rules. For a literature review and additional qualitative discussion on the vehicle cycle and its impacts, readers should refer to FEIS Chapter 6 (Lifecycle Analysis) (See III.F as well). Other commenters have been just as adamant that BEVs offer lifetime maintenance and repair benefits.

NHTSA notes that due to statutory constraints on considering the fuel economy of BEVs and the full fuel economy of PHEVs in determining maximum feasible CAFE standards, any change in maintenance and repair costs due to electrification would have a limited impact on NHTSA's analysis comparing alternatives. Given that this topic is still emerging, and that the results would not affect the agency's decision given the statutory constraint on consideration of BEV fuel economy in determining maximum feasible CAFE standards, the agency believes it is reasonable not to attempt to model these benefits or costs in this final rule. See Section VI.A on economic practicability for discussion on affordability impacts more generally.

Consumer Reports commented that hybrid-cost effectiveness is, on average, better than that of non-hybrids due to maintenance and repair cost savings over time, citing their 2023 analysis focusing on ten bestselling hybrids and their ICE counterparts.[793] NHTSA is continuing to study the relative maintenance and repair costs associated with adopting fuel saving technologies. In order to conduct this analysis properly NHTSA would require more granular data on a larger set of technologies than what is included in Consumer Reports' study and would also need to estimate the effects of changes in vehicle usage on these costs. NHTSA will continue to consider these costs in the future as more information becomes available.

The second empty line item in the table is the value of potential sacrifices in other vehicle attributes. Some technologies that are used to improve fuel economy could have also been used to increase other vehicle attributes, especially performance, carrying capacity, comfort, and energy-using accessories, though some technologies can also increase both fuel economy and performance simultaneously. While this is most obvious for technologies that improve the efficiency of engines and transmissions, it may also be true of technologies that reduce mass, aerodynamic drag, rolling resistance or any road or accessory load. The exact nature of the potential to trade-off attributes for fuel economy varies with specific technologies, but at a minimum, increasing vehicle efficiency or reducing loads allows a more powerful engine to be used while achieving the same level of fuel economy. Performance is held constant in our analysis. However, if a consumer values a performance attribute that cannot be added to a vehicle because fuel economy improvements have ''used up'' the relevant technologies, or if vehicle prices become too high wherein either a consumer cannot obtain additional financing or afford to pay more for a vehicle within their household budget that consumers may opt to purchase vehicles that are smaller or lack features such as heated seats, advanced entertainment or convenience systems, advance safety systems, or panoramic sunroofs, that the consumer values but are unrelated to the performance of the drivetrain.[794] Alternatively, manufacturers may voluntarily preclude these features from certain models or limit the development of other new features in anticipation that new vehicle price affordability will limit the amount they may be able to charge for these new features. How consumers value increased fuel economy and how fuel economy regulations affect manufacturers' decisions about using efficiency-improving technologies can have important effects on the estimated costs, benefits, and indirect impacts of fuel economy standards. Nevertheless, any sacrifice in potential improvements to vehicles' other attributes could represent a net opportunity cost to their buyers (though performance-efficiency tradeoffs could also lower compliance costs, and some additional attributes, like acceleration, could come with their own countervailing social costs).[795]

NHTSA has previously attempted to model the potential sacrifice in other vehicle attributes in sensitivity analyses by assuming the opportunity cost must be greater than some percentage of the fuel savings they seemingly voluntarily forego. In those previous rulemakings, NHTSA acknowledged that it is extremely difficult to quantify the potential loss of other vehicle attributes, and therefore included the value of other vehicle attributes only in sensitivity analyses. This approach is used as a sensitivity analysis for the final rule and is discussed in RIA 9.2.3. This approach is only relevant if the

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[791] Heritage Foundation-Mario Loyola, Docket No. NHTSA–2023–0022–61952; American Consumer Institute, Docket No. NHTSA–2023–0022–50765; AFPM, Docket No. NHTSA–2023–0022–61911.

[792] West Virginia Attorney General's Office, Docket No. NHTSA–2023–0022–63056–A1, at 11.

[793] Consumer Reports, Docket No. NHTSA–2023–0022–61098–A1, at 1–2.

[794] NHTSA notes that if consumers simply take out a larger loan, then some future consumption is replaced by higher principle and interest payments in the future.

[795] This is similar to the phenomena described in The Bernie Mac Show: My Privacy (Fox Broadcasting Company Jan. 14, 2005). After an embarrassing incident caused by too few bedrooms, Bernie Mac decides to renovate his house. A contractor tells Mr. Mack that he can have the renovations performed ''good and fast,'' ''good and cheap,'' or ''fast and cheap,'' but it was impossible to have ''good, fast, and cheap.''

foregone fuel savings cannot be explained by the energy paradox.

The results of NHTSA's analysis of the HDPUV standards suggest that buyer's perceived reluctance to purchasing higher-mpg models is due to undervaluation of the expected fuel savings due to market failures, including short-termism, principal-agent split incentives, uncertainty about the performance and service needs of new technologies and first-mover disadvantages for consumers, uncertainty about the resale market, and market power and first-mover disadvantages among manufacturers. This result is the same for vehicles purchased by individual consumers and those bought for commercial purposes. NHTSA tested the sensitivity of the analysis to the potential that the market failures listed do not apply to the commercial side of the HDPUV market. In this sensitivity analysis, commercial operators are modeled as profit maximizers who would not be made more or less profitable by more stringent standards by offsetting the estimated net private benefit to commercial operators.[796] NHTSA decided against including this alternative in the primary analysis to align with its approach to market failures in the light-duty analysis. Furthermore, there is insufficient data on the size and composition of the commercial share of the HDPUV market to develop a precise estimate of a commercial operator opportunity cost. For additional details, see Chapter 9.2.3.10 of the FRIA.

Several commenters argued that NHTSA's assumption that increases in fuel economy to meet the new standards are not accompanied by foregone vehicle performance leads to an overestimate of net-benefits from increasing standards.[797] [798] For example Valero commented that ''NHTSA offer[ed] no convincing rationale for omitting foregone performance gains from the central-case analysis'' and claimed ''NHTSA does its best to completely avoid the performance issue.'' [799] IPI shared a similar belief and commented that ''NHTSA should further highlight [the implicit opportunity cost] sensitivity results.'' [800] NHTSA agrees with IPI that it could do a better job highlighting the results of sensitivities that stakeholders considered, especially ones like the implicit opportunity cost which some commenters felt were either missing or underrepresented.

More specifically, Landmark argued that improvements in fuel economy necessitate performance tradeoffs to reduce the weight of vehicles.[801] Other commenters argued that there is evidence that in the absence of changes to standards manufacturers have chosen to make further improvements to performance features of vehicles, and that similar future improvements to performance would be sacrificed by manufacturers in order to comply with the standards NHTSA proposed, and thus should be counted as incremental consumer costs.[802]

Valero, CEA, and NADA referenced a recent paper from Leard, Linn, and Zhou (2023), who estimate that this opportunity cost of fuel economy improvement could offset much of the private fuel cost savings benefits that consumers receive from the increase in stringency of standards. The authors of this paper estimate that consumers value improvements in acceleration much more highly than the fuel economy improvements that manufacturers trade them off for in an effort to comply with higher standards. However, the authors of this paper note that their study does not account for the potential induced innovations from tightened standards, or market failures associated with imperfect competition in the new vehicle market. NHTSA discussed this paper in its proposal, but recognized the limitations that the authors noted, as well as the degree of uncertainty in the literature regarding the implicit opportunity cost of fuel economy standards.

Valero suggests that in the absence of higher standards, manufacturers would channel investment into improvements in vehicle performance, which is foregone when standards are raised. As a result, Valero commented that fuel economy standards cause performance to increase less than it would in the absence of standards and referenced the findings of Klier and Linn (2016).[803] NHTSA also discussed this paper in its proposal (see PRIA Chapter 9). The authors of the paper note that during the period they examined, for passenger cars in the United States there was no statistically significant evidence that stringency affected the direction of technology adoption between fuel efficiency and either horsepower or weight (the two attributes considered). While the authors do find evidence of an effect on this tradeoff for light trucks, they admit that there is significant uncertainty over the consumer's willingness to pay for this foregone performance (indeed they do not quantify the dollar value of the effect on vehicle weight due to this uncertainty). Recent data also casts doubt on Valero's deterministic understanding of the relationship between tightening standards and vehicle performance. Between 2000 and 2010 CAFE standards for passenger cars were unchanged. According to the 2023 EPA Automotive Trends report, real world fuel economy for vehicles rose at a rate of about 1.3 percent per year during this period, while horsepower rose at a rate of 1.2 percent, weight increased at a rate of 0.4 percent, and acceleration as measured by 0 to 60 miles per hour time declined at an average rate of 0.8 percent.[804] Between 2010 and 2023, standards increased substantially and the fuel economy of these vehicles has improved at a rate of around 2.4 percent per year over this period. However, this has not caused improvements in other attributes to slow down. Instead, weight (0.5 percent), horsepower (1.7 percent), and 0 to 60 time (−1.4 percent) all improved at faster rates than the previous period. While these attributes could have potentially improved at still greater rates in the absence of standards, these headline values suggest that standards have at least not caused a significant slow-down relative to prior trends. Also, as noted in FRIA Chapter 9, other research suggests that consumers have not had to tradeoff performance for fuel economy improvements, and should not be expected to in the future, due to fuel saving technologies whose adoption does not lead to adverse effects on the performance of vehicles (Huang, Helfand, et al. 2018; Watten, Helfand and Anderson 2021; Helfand and Dorsey-Palmateer 2015). Indeed, there are technologies that exist that provide

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[796] Relevant sensitivity cases are labeled ''Commercial Operator Sales Share'' and denote the percent of the fleet assumed owned by commercial operators. NHTSA calculates net private benefits as the sum of technology costs, lost consumer surplus from reduced new vehicle sales, and safety costs internalized by drivers minus fuel savings, benefits from additional driving, and savings from less frequent refueling.

[797] Examples of performance related attributes listed by commenters included: horsepower, horsepower per pound of vehicle weight, acceleration, towing capacity, and torque.

[798] Landmark, Docket No. NHTSA–2023–0022–48725, at 4; Valero, Docket No. NHTSA–2023–0022–58547, Attachment E, at 1–4; KCBA, Docket No. NHTSA–2023–0022–59007, at 4; AmFree, Docket No. NHTSA–2023–0022–62353, at. 5.

[799] Valero, Docket No. NHTSA–2023–0022–58547, Attachment E, at 3, 5.

[800] IPI, Docket No. NHTSA–2023–0022–60485, at 31–32.

[801] Landmark, Docket No. NHTSA–2023–0022–48725, at 4.

[802] Valero, Docket No. NHTSA–2023–0022–58547, Attachment E, at 1, 3.

[803] Valero, Docket No. NHTSA–2023–0022–58547, Attachment E, at 1.

[804] 2023 EPA Automotive Trends Report, Available at: *https://www.epa.gov/automotive-trends/explore-automotive-trends-data#DetailedData,* (Accessed: April 18, 2024).

improved fuel economy without hindering performance, and in some cases, also improve performance (such as high-strength aluminum alloy bodies, turbocharging, and increasing the number of gear ratios in new transmissions). Even as the availability of more fuel-efficient vehicles has increased steadily over time, research has shown that the attitudes of drivers towards those vehicles with improved fuel economy has not been affected negatively. To the extent some performance-efficiency tradeoffs may have occurred in the past, such tradeoffs may decline over time, with technological advancements and manufacturer learning over longer vehicle design periods (Bento 2018; Helfand & Wolverton 2011).

NHTSA thus maintains that there is significant uncertainty in the literature over the degree to which changes in fuel economy standards will cause manufacturers to lower the performance of vehicles, and how much this will be valued by consumers. Indeed, the possibility that there are ancillary benefits to adopting fuel saving technology means that the directionality of the effect of excluding these additional attributes from the central analysis is unknown. In its analysis, NHTSA assumes that the performance features listed by commenters remain fixed across alternatives, and that manufacturers instead adopt fuel economy improving technology in order to comply with standards without reducing the quality of those features. NHTSA assumes that manufacturers are aware of consumers' willingness to pay for performance features like those noted by the commenters and would be reluctant to make sacrifices to them as part of their compliance strategies. This, of course, is not the only path to compliance for manufacturers. However, given uncertainty over consumer willingness to pay for the full set of potentially affected attributes, the long-term pricing strategies of firms, and firm specific costs, it is a reasonable approach for NHTSA to use when modeling the behavior of all manufacturers in the market. Modeling the decisions of all manufacturers over the complete set of attributes and technologies available would lead to a computationally infeasible model of compliance. Moreover, without highly detailed data about the manufacturing process of each manufacturer and vehicle model, it could introduce significant opportunities for errors in the agency's measurements of compliance costs. Omitting ancillary benefits and only including the attributes that could be traded off for fuel savings improvements by firms could bias the agency's analysis. Absent a better understanding of consumer willingness to pay for these other attributes, including them would create a misleading model of how firms would choose to comply with the standards as well as how consumer welfare would be affected. While commenters suggested that the performance neutrality assumption in NHTSA's analysis is unrealistic, they did not propose an alternative methodology for modeling how manufacturers would adjust performance attributes in response to changes in CAFE Standards.[805] This performance neutrality assumption is intended to isolate the impacts of the standards and is necessary with or without a separate estimation of a potential implicit opportunity cost. Since NHTSA believes that its assumption of performance neutrality is a reasonable approach to modeling compliance, and since alternative approaches would introduce highly uncertain effects (with unknown directionality) and are currently infeasible, NHTSA has chosen to maintain its assumption of performance neutrality.[806]

NHTSA does take seriously the possibility of opportunity costs as described by these commenters. For this reason, the agency included sensitivity cases in its analysis for both light duty and HDPUV in Chapter 9 of the PRIA and FRIA. In this sensitivity case, the opportunity cost of fuel economy for light duty vehicles is assumed to be equal to the discounted fuel cost savings for a vehicle over its first 72 months of use (roughly how long they are held, on average, by their first owner), less the undiscounted fuel cost savings over the first 30 months of use. NHTSA believes that this is a reasonable approach, since this value is equivalent to the value of fuel savings that new vehicle owners are assumed to not value in their purchase decision.[807] If consumers are not myopic and value fuel savings fully, and assuming perfect information and no market distortions, then offsetting losses in performance would be at least this high. For HDPUVs, NHTSA also considered two additional sensitivity cases in which it assumed that this opportunity cost fully offset any net private benefits of fuel economy improvements for commercial buyers.[808] This higher value for opportunity cost for commercial buyers was based on the assumption that commercial buyers are more likely to fully value the lifetime fuel savings of their fleet vehicles, since these buyers are profit maximizing businesses. As noted by IPI in its comments, NHTSA found in the proposal that while net social benefits under the preferred alternative are lower under these alternative assumptions, under 3 percent discounting they remain positive in all cases.[809] This is caused by reductions in emissions externalities offsetting increases in safety externalities. NHTSA conducted similar sensitivity exercises in its final rule and found that societal net benefits remained positive in the preferred alternative regardless of discount rate. Since neither of these cases include the potential ancillary benefits of fuel saving technology adoption, and do not take into account the full set of compliance methods that manufacturers could employ to meet the standards in a cost effective way, NHTSA views these cases as bounding exercises that allow the agency to see whether a relatively high estimate of the potential opportunity costs of the standards outweigh the other net societal benefits included in NHTSA's analysis. Valero suggested that the agency's analysis of the implicit opportunity cost should equal to all private fuel savings.[810] We disagree for several reasons. First, the average consumer will not hold onto new vehicles for a vehicle's entire lifetime, and even if the first owner valued all of the forgone attributes at the price of fuel savings, the second or third owner would have her own set of preferences that likely do not overlap the first owner's perfectly. Second, assigning a specific dollar value on vehicle luxuries is likely difficult for consumers, and there is a tendency for vehicle buyers to splurge at the dealership only to regret overspending when the monthly payments become due. For example, a Lending Tree survey found that 14 percent of car buyers wish *ex post* that they had chosen a different make or model, 10

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[805] Valero, Docket No. NHTSA–2023–0022–58547, Attachment E, at 3–4; CEA, Docket No. NHTSA–2023–0022–61918, at 20.

[806] *See* Section II.C.6 for further details.

[807] Kelly Blue Book, ''Average length of U.S. vehicle ownership hit an all-time high'', Feb. 23, 2012, Available at: *https://www.kbb.com/car-news/average-length-of-us-vehicle-ownership-hit-an-all_time-high/#:~:text=The%20latest%20data%20compiled%20by%20global%20market%20intelligence,figure%20that%20also%20represents%20a%20new%20high%20mark.* (Accessed: April 29, 2024).

[808] NHTSA simulated a case in which half of HDPUV buyers were commercial buyers, and a cases in which all HDPUV buyers were commercial buyers.

[809] IPI, Docket No. NHTSA–2023–0022–60485, at 34.

[810] Valero, Docket No. NHTSA–2023–0022–58547, Attachment E, at 4.

percent bought too expensive of a car, 4 percent bought a more expensive car than they planned, and 3 percent noted they regretted buying features they did not need.[811] Similarly, not all vehicle attributes are offered à la carte (some vehicle attributes are sometimes only available in packages with other additions or require consumers to purchase higher trims) and consumers may only value one or two items in a larger package and are stuck buying as a bundle.

H. Simulating Safety Effects of Regulatory Alternatives

The primary objective of the standards is to achieve maximum feasible fuel economy and fuel efficiency, thereby reducing fuel consumption. In setting standards to achieve this intended effect, the potential of the standards to affect vehicle safety is also considered. As a safety agency, NHTSA has long considered the potential for adverse or positive safety consequences when establishing fuel economy and fuel efficiency standards.

This safety analysis includes the comprehensive measure of safety impacts of the light-duty and HDPUV standards from three sources:

- Changes in Vehicle Mass

Similar to previous analyses, NHTSA calculates the safety impact of changes in vehicle mass made to reduce fuel consumption to comply with the standards. Statistical analysis of historical crash data indicates reducing mass in heavier vehicles generally improves safety for occupants in lighter vehicles and other road users like pedestrians and cyclists, while reducing mass in lighter vehicles generally reduces safety. NHTSA's crash simulation modeling of vehicle design concepts for reducing mass revealed similar effects. These observations align with the role of mass disparity in crashes; when vehicles of different masses collide, the smaller vehicle will experience a larger change in velocity (and, by extension, force), which increases the risk to its occupants. NHTSA believes the most recent analysis represents the best estimate of the impacts of mass reduction (MR) on crash fatalities attributable to changes in mass disparities., One caveat to note is that the best estimates are not significantly different from zero and are not statistically significant at the 95th confidence level. In other words, the effects of changes in mass due to this rule cannot be distinguished from zero.

Two individuals, Mario Loyola and Steven G. Bradbury, submitted a joint comment (referred to herein as ''Loyola and Bradbury''), speculating that the agency is ''downplay[ing] and minimize[ing] the loss of lives and serious injuries [the] standards [caused] by attributing many of these deaths and injuries to other regulators.'' [812] The commentors would have the agency include fatalities that are projected to occur in the reference baseline as attributable t' this rule. While NHTSA's analysis includes the impacts of other regulations in the reference baseline, it does not separate the safety impacts attributable to individual regulations. Instead, the analysis considers the aggregate impact of these other regulations for comparison with the impacts of CAFE standards. NHTSA does not have information, nor do the commenters provide any specific information, indicating that the inclusion of the impacts of these other regulations results in undercounting of safety impacts attributable to the Preferred Alternative. The purpose of calculating a reference baseline is to show the world in the absence of further government action. If NHTSA chose not to finalize the standards, the agency believes that the reference baseline fatalities would still occur. As such, we disagree with the authors' proposed suggestion.

- Impacts of Vehicle Prices on Fleet Turnover

Vehicles have become safer over time through a combination of new safety regulations and voluntary safety improvements. NHTSA expects this trend to continue as emerging technologies, such as advanced driver assistance systems, are incorporated into new vehicles. Safety improvements will likely continue regardless of changes in the standards.

As discussed in Section III.E.2, technologies added to comply with fuel economy and efficiency standards have an impact on vehicle prices, therefore slowing the acquisition of newer vehicles and retirement of older ones. The delay in fleet turnover caused by the effect of new vehicle prices affect safety by slowing the penetration of new safety technologies into the fleet.

The standards also influence the composition of the light-duty fleet. As the safety provided by light trucks, SUVs and passenger cars responds differently to technology that manufacturers employ to meet the standards—particularly mass reduction—fleets with different compositions of body styles will have varying numbers of fatalities, so changing the share of each type of light-duty vehicles in the projected future fleet impacts safety outcomes.

- Increased Driving Because of Better Fuel Economy

The ''rebound effect'' predicts consumers will drive more when the cost of driving declines. More stringent standards reduce vehicle operating costs, and in response, some consumers may choose to drive more. Additional driving increases exposure to risks associated with motor vehicle travel, and this added exposure translates into higher fatalities and injuries. However, most fatalities associated with rebound driving are the result of consumers choosing to drive more. Therefore, most of the societal safety costs of rebound vehicle travel are offset in our net benefits analysis.

The contributions of the three factors described above generate the differences in safety outcomes among regulatory alternatives. NHTSA's analysis makes extensive efforts to allocate the differences in safety outcomes between the three factors. Fatalities expected during future years under each alternative are projected by deriving a fleet-wide fatality rate (fatalities per vehicle mile of travel) that incorporates the effects of differences in each of the three factors from reference baseline conditions and multiplying it by that alternative's expected VMT. Fatalities are converted into a societal cost by multiplying fatalities with the DOT-recommended value of a statistical life (VSL) supplemented by economic impacts that are external to VSL measurements. Traffic injuries and property damage are also modeled directly using the same process and valued using costs that are specific to each injury severity level.

All three factors influence predicted fatalities, but only two of them—changes in vehicle mass and in the composition of the light-duty fleet in response to changes in vehicle prices—impose increased risks on drivers and passengers that are not compensated for by accompanying benefits. In contrast, increased driving associated with the rebound effect is a consumer choice that reveals the benefits of additional travel. Consumers who choose to drive more have apparently concluded that the utility of additional driving exceeds the additional costs for doing so, including the crash risk that they perceive

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[811] J. Jones, D. Shepard, X. Martinez-White. Lending Tree. Nearly Half Who Bought a Car in the Past Year Have Regrets. Jan 24, 2022. Available at *https://www.lendingtree.com/auto/car-regrets-survey/* (Accessed: April 18, 2024).

[812] Heritage Foundation, Docket No. NHTSA–2023–0022–61952, at 8.

additional driving involves. As discussed in Chapter 7 of the final TSD, the benefits of rebound driving are accounted for by offsetting a portion of the added safety costs.

For the safety component of the analysis for this final rule, NHTSA assumed that HDPUVs have the same risk exposure as light trucks. Given that the HDPUV fleet is significantly smaller than the light-duty fleet, the sample size to derive safety coefficients separately for HDPUVs is challenging. We believe that HDPUVs share many physical commonalities with light trucks and the incidence and crash severity are likely to be similar. As such, we concluded it was appropriate to use the light truck safety coefficients for HDPUVs.

NHTSA is continuing to use the proposal's approach of including non-occupants in the analysis. The agency categorizes safety outcome through three measures of light-duty and HDPUV vehicle safety: fatalities occurring in crashes, serious injuries, and the amount of property damage incurred in crashes with no injuries. Counts of fatalities to occupants of automobiles and non-occupants are obtained from NHTSA's Fatal Accident Reporting System. Estimates of the number of serious injuries to drivers and passengers of light-duty and HDPUV vehicles are tabulated from NHTSA's General Estimates System (GES) for 1990–2015, and from its Crash Report Sampling System (CRSS) for 2016–2019. Both GES and CRSS include annual samples of motor vehicle crashes occurring throughout the United States. Weights for different types of crashes were used to expand the samples of each type to estimates of the total number of crashes occurring during each year. Finally, estimates of the number of automobiles involved in property damage-only crashes each year were also developed using GES.

NHTSA sought comment on its safety assumptions and methodology in the proposal.

1. Mass Reduction Impacts

Vehicle mass reduction can be one of the more cost-effective means of improving efficiency, particularly for makes and models not already built with much high-strength steel or aluminum closures or low-mass components. Manufacturers have stated that they will continue to reduce mass of some of their models to meet more stringent standards, and therefore, this expectation is incorporated into the modeling analysis supporting the standards. Safety trade-offs associated with mass-reduction have occurred in the past, particularly before standards were attribute-based because manufacturers chose, in response to standards, to build smaller and lighter vehicles; these smaller, lighter vehicles did not fare as well in crashes as larger, heavier vehicles, on average. Although NHTSA now uses attribute-based standards, in part to reduce or eliminate the incentive to downsize vehicles to comply with the standards, NHTSA must be mindful of the possibility of related safety trade-offs. For this reason, NHTSA accounts for how the application of MR to meet standards affects the safety of a specific vehicle given changes in GVWR.

For this final rule, the agency employed the modeling technique, which was developed in the 2016 Puckett and Kindelberger report and used in the proposal, to analyze the updated crash and exposure data by examining the cross sections of the societal fatality rate per billion vehicle miles of travel (VMT) by mass and footprint, while controlling for driver age, gender, and other factors, in separate logistic regressions for five vehicle groups and nine crash types. NHTSA utilized the relationships between weight and safety from this analysis, expressed as percentage increases in fatalities per 100-pound weight reduction (which is how MR is applied in the technology analysis; see Section III.D.4), to examine the weight impacts applied in this analysis. The effects of MR on safety were estimated relative to (incremental to) the regulatory reference baseline in the analysis, across all vehicles for MY 2021 and beyond. The analysis of MR includes two opposing impacts. Research has consistently shown that MR affects ''lighter'' and ''heavier'' vehicles differently across crash types. The 2016 Puckett and Kindelberger report found MR concentrated among the heaviest vehicles is likely to have a beneficial effect on overall societal fatalities, while MR concentrated among the lightest vehicles is likely to have a detrimental effect on occupant fatalities but a slight benefit to pedestrians and cyclists. This represents a relationship between the dispersion of mass across vehicles in the fleet and societal fatalities: decreasing dispersion is associated with a decrease in fatalities. MR in heavier vehicles is more beneficial to the occupants of lighter vehicles than it is harmful to the occupants of the heavier vehicles. MR in lighter vehicles is more harmful to the occupants of lighter vehicles than it is beneficial to the occupants of the heavier vehicles.

To accurately capture the differing effect on lighter and heavier vehicles, NHTSA splits vehicles into lighter and heavier vehicle classifications in the analysis. However, this poses a challenge of creating statistically meaningful results. There is limited relevant crash data to use for the analysis. Each partition of the data reduces the number of observations per vehicle classification and crash type, and thus reduces the statistical robustness of the results. The methodology employed by NHTSA was designed to balance these competing forces as an optimal trade-off to accurately capture the impact of mass-reduction across vehicle curb weights and crash types while preserving the potential to identify robust estimates.

Loyola and Bradbury commented that smaller and lighter vehicles built in response to the standards will increase the number of fatalities but did not note any deficiencies in the agency's analysis or consideration of mass-safety impacts.[813] ACC and the Joint NGOs commented that changes in vehicle design and materials technology may lead to changes in relationships among vehicle mass and safety outcomes.[814] NHTSA has acknowledged this potential outcome across multiple rulemakings and has continued to keep abreast of any new developments; however, for the time being, NHTSA feels there is insufficient data to support alternative estimates. NRDC further commented that manufacturers are capable of applying MR to a greater degree in heavier vehicles, yielding a net safety benefit to society. The CAFE Model incorporates the relationship raised by NRDC and the mass-size-safety coefficients applied in the model yield results consistent with this relationship when MR is applied to heavier vehicles more than lighter vehicles.

Multiple stakeholders commented that NHTSA failed to adequately account for changes in vehicle mass associated with changing from ICE to BEV platforms for a given vehicle model in the analysis of the reference baseline.[815] In related comments, ACC and the Aluminum Association noted that BEVs are likely to have different safety profiles than ICE vehicles. We note, however, that there are no safety impacts resulting from a shift from ICE

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[813] Heritage Foundation, Docket No. NHTSA–2023–0022–61952, at 8.

[814] ACC, Docket No. NHTSA–2023–0022–60215, at 6 and 8–9; Joint NGOs, Docket No. NHTSA–2023–0022–61944–2, at 72–3.

[815] *See, e.g.,* ACC, Docket No. NHTSA–2023–0022–60215, at 8–9; Valero, Docket No. NHTSA–2023–0022–58547–2, at 7–8; KCGA, Docket No. NHTSA–2023–0022–59007, at 4–5; The Aluminum Association, Docket No. NHTSA–2023–0022–58486, at 4; Arconic, Docket No. NHTSA–2023–0022–48374, at 2.

to BEV platforms in NHTSA's central analysis of the impact of CAFE standards because NHTSA's model is constrained such that no BEVs are added to the fleet during standard-setting years as a result of an increase in the stringency of CAFE standards. That is, any shift from ICE vehicles to BEVs in the standard setting years is limited to actions occurring in the reference baseline. In our analysis of the reference baseline, we account for an expected increase in BEVs as a result of market forces (like manufacturers' expected deployment of electric vehicles consistent with levels required by California's ACC II program) and regulatory requirements. However, while we acknowledge that, all else equal, vehicle masses likely increase when shifting from ICE to BEV platforms and BEVs may have distinct safety characteristics relative to ICE vehicles across crash types, we have insufficient data to account for how safety outcomes would be affected by shifting from ICE to BEV platforms in the analysis of the reference baseline, including insufficient information to justify an assumption that changes in mass associated with BEV structural differences are equivalent to changes in mass within ICE platforms. The CAFE Model is not currently designed to account for differences in vehicle mass associated with changes from ICE to BEV platforms. We are conducting research to address this lack of data in future rulemakings, but for this rule in the absence of sufficient data we have chosen to assume a neutral net safety effect for mass (and center of gravity) changes associated with shifts from ICE to BEV platforms for a given vehicle model in the baseline analysis. We acknowledge that ICE and BEV platforms for otherwise equivalent vehicles may differ in center of gravity, frontal crush characteristics, and acceleration. This creates uncertainty as to the validity of extrapolating observed mass-safety relationships from ICE vehicles to BEVs, however, until there is sufficient data and research to uncover an alternative relationship for BEVs, we believe that our current approach is reasonable.

The Joint NGOs and Consumer Reports also commented that the estimated mass-size-safety coefficients are statistically insignificant.[816] [817] We have acknowledged this relationship in this rulemaking along with previous rulemakings where the estimated coefficients are not statistically significant at the 95 percent confidence level. In this rulemaking, the distinction between using insignificant estimates and zeroes is functionally moot because the estimated societal safety impacts associated with changes in vehicle mass associated with the rule are estimated to be zero in the Preferred Alternative. Furthermore, courts have discouraged agencies from excluding specific costs or benefits because the magnitude is uncertain.[818] Given the agency believes that the point estimates still represent the best available data, NHTSA continues to include a measurement of mass-safety impacts in its analysis.

A more detailed description of the mass-safety analysis can be found in Chapter 7.2 of the Final TSD.

2. Sales/Scrappage Impacts

The sales and scrappage responses to higher vehicle prices discussed in Section III.E.2 have important safety consequences and influence safety through the same basic mechanism, fleet turnover. In the case of the scrappage response, delaying fleet turnover keeps drivers in older vehicles which tend to be less safe than newer vehicles. Similarly, the sales response slows the rate at which newer vehicles, and their associated safety improvements, enter the on-road population. The sales response also influences the mix of vehicles on the road–with more stringent CAFE standards leading to a higher share of light trucks sold in the new vehicle market, assuming all else is equal. Light trucks have higher rates of fatal crashes when interacting with passenger cars and as earlier discussed, different directional responses to MR technology based on the existing mass and body style of the vehicle.

Any effect on fleet turnover (either from delayed vehicle retirement or deferred sales of new vehicles) will affect the distribution of both ages and MYs present in the on-road light duty and HDPUV fleets. Because each of these vintages carries with it inherent rates of fatal crashes, and newer vintages are generally safer than older ones, changing that distribution will change the total number of on-road fatalities under each regulatory alternative. Similarly, the Dynamic Fleet Share (DFS) model captures the changes in the light-duty fleet's composition of cars and trucks. As cars and trucks have different fatality rates, differences in fleet composition across the alternatives will affect fatalities.

At the highest level, NHTSA calculates the impact of the sales and scrappage effects by multiplying the VMT of a vehicle by the fatality risk of that vehicle. For this analysis, calculating VMT is rather simple: NHTSA uses the distribution of miles calculated in Chapter 4.3 of the Final TSD. The trickier aspect of the analysis is creating fatality rate coefficients. The fatality risk measures the likelihood that a vehicle will be involved in a fatal accident per mile driven. NHTSA calculates the fatality risk of a vehicle based on the vehicle's MY, age, and style, while controlling for factors that are independent of the intrinsic nature of the vehicle, such as behavioral characteristics. Using this same approach, NHTSA designed separate models for fatalities, non-fatal injuries, and property damaged vehicles.

The vehicle fatality risk described above captures the historical evolution of safety. Given that modern technologies are proliferating faster than ever and offer greater safety benefits than traditional safety improvements, NHTSA augmented the fatality risk projections with knowledge about forthcoming safety improvements. NHTSA applied estimates of the market uptake and improving effectiveness of crash avoidance technologies to estimate their effect on the fleet-wide fatality rate, including explicitly incorporating both the direct effect of those technologies on the crash involvement rates of new vehicles equipped with them, as well as the "spillover" effect of those technologies on improving the safety of occupants of vehicles that are not equipped with these technologies.

NHTSA's approach to measuring these impacts is to derive effectiveness rates for these advanced crash-avoidance technologies from safety technology literature. NHTSA then applies these effectiveness rates to specific crash target populations for which the crash avoidance technology is designed to mitigate, which are then adjusted to reflect the current pace of adoption of the technology, including any public commitment by manufacturers to install these technologies. These technologies include Forward Collision Warning, Automatic Emergency Braking, Lane Departure Warning, Lane Keep Assist, Blind Spot Detection, Lane Change Assist, and Pedestrian Automatic Emergency Braking. The products of these factors, combined across all 7 advanced technologies, produce a fatality rate reduction percentage that is applied to the fatality rate trend model discussed above, which projects both

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[816] Joint NGOs, Docket No. NHTSA–2023–0022–61944–2, at 72–3.

[817] Consumer Reports, Docket No. NHTSA–2023–0022–61098, at 18.

[818] *CBD* v. *NHTSA,* 538 F.3d 1172, 1198 (9th Cir. 2008).

vehicle and non-vehicle safety trends. The combined model produces a projection of impacts of changes in vehicle safety technology as well as behavioral and infrastructural trends. A much more detailed discussion of the methods and inputs used to make these projections of safety impacts from advanced technologies is included in Chapter 7.1 of the Final TSD.

Loyola and Bradbury commented that the slowing of fleet turnover in response to the standards will increase fatalities but did not note any deficiencies in the agency's analysis or consideration of fleet turnover impacts.[819] As such, the agency believes it has appropriately considered the issue the commenters raised.

Consumer Reports cited the sensitivity and uncertainty of NHTSA's sales module, including the dynamic fleet share component and scrappage model, and questioned the astuteness of including the safety impacts from these effects. Consumer Reports also noted that they have not observed these effects in practice. NHTSA thanks Consumer Reports for providing their research in their comments. While the agency believes their research is valuable, we were unable to arrive at the same conclusions.[820]

3. Rebound Effect Impacts

The additional VMT demanded due to the rebound effect is accompanied by more exposure to risk, however, rebound miles are not imposed on consumers by regulation. They are a freely chosen activity resulting from reduced vehicle operational costs. As such, NHTSA believes a large portion of the safety risks associated with additional driving are offset by the benefits drivers gain from added driving. The level of risk internalized by drivers is uncertain. This analysis assumes that drivers of both HDPUV and light duty vehicles internalize 90 percent of this risk, which mostly offsets the societal impact of any added fatalities from this voluntary consumer choice. Additional discussion of internalized risk is contained in Chapter 7.5 of the TSD.

Consumer Reports commented that there is ''no evidence whatsoever to support NHTSA's assumption that consumers internalize only 90% of the safety risk'' and asks the agency to offset the entirety of rebound fatalities.[821] Alternatively, Consumer Reports suggests that even though the agency's logic is sound for offsetting externality risks, if the risk were not internalized, because rebound driving is voluntary, it is still inappropriate to account for the increased fatality risks. Consumer Reports also expressed concern about the precedent of accounting for additional driving when consumers save money. The agency appreciates Consumer Reports comment but has chosen not to adjust its approach to offsetting rebound safety for the final rule. We agree with Consumer Reports that there is a dearth of evidence to support a 90 percent offset, but the agency also notes that there is no evidence to support a higher offset either. Accounting for rebound effects does not set a broader precedent beyond fuel efficiency rules. The rebound effect is generally recognized to be the phenomena of using more of an energy consuming product when its operating costs decline rather than how consumers will use energy consuming products as their income increases.

4. Value of Safety Impacts

Fatalities, nonfatal injuries, and property damage crashes are valued as a societal cost within the CAFE Model's cost and benefit accounting. Their value is based on the comprehensive value of a fatality, which includes lost quality of life and is quantified in the VSL as well as economic consequences such as medical and emergency care, insurance administrative costs, legal costs, and other economic impacts not captured in the VSL alone. These values were first derived from data in Blincoe et al. (2015), updated in Blincoe et al. (2023), and adjusted to 2021 dollars, and updated to reflect the official DOT guidance on the VSL.

Nonfatal injury costs, which differ by severity, were weighted according to the relative incidence of injuries across the Abbreviated Injury Scale (AIS). To determine this incidence, NHTSA applied a KABCO/MAIS translator to CRSS KABCO based injury counts from 2017 through 2019. This produced the MAIS-based injury profile. This profile was used to weight nonfatal injury unit costs derived from Blincoe et al. (2023), adjusted to 2021 economics and updated to reflect the official DOT guidance on the VSL. Property-damaged vehicle costs were also taken from Blincoe et al (2023). and adjusted to 2021 economics.

For the analysis, NHTSA assigns a societal value of $12.2 million for each fatality, $181,000 for each nonfatal injury, and $8,400 for each property damaged vehicle. As discussed in the previous section, NHTSA discounts 90% of the safety costs associated with the rebound effect. The remaining 10% of those safety costs are not considered to be internalized by drivers and appear as a cost of the standards that influence net benefits. Similarly, the effects on safety attributable to changes in mass and fleet turnover are not considered costs internalized by drivers since manufacturers are responsible for deciding how to design and price vehicles. The costs not internalized by drivers is therefore the summation of the mass-safety effects, fleet turnover effects, and the remaining 10% of rebound-related safety effects.

IV. Regulatory Alternatives Considered in This Final Rule

A. General Basis for Alternatives Considered

Agencies typically consider regulatory alternatives in order to evaluate the comparative effects of different potential ways of implementing their statutory authority to achieve their intended policy goals. NEPA requires agencies to compare the potential environmental impacts of their actions to a reasonable range of alternatives. E.O. 12866 and E.O. 13563, as well as OMB Circular A–4, also request that agencies evaluate regulatory alternatives in their rulemaking analyses.

Alternatives analysis begins with a ''No-Action'' Alternative, typically described as what would occur in the absence of any further regulatory action by the agency. OMB Circular A–4 states that ''the choice of an appropriate baseline may require consideration of a wide range of potential factors, including:

- evolution of markets;
- changes in regulations promulgated by the agency or other government entities;
- other external factors affecting markets;
- the degree of compliance by regulated entities with other regulations; and
- the scale and number of entities or individuals that will be subject to, or experience the benefits or costs of, the regulation.'' [822]

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[819] Heritage Foundation, Docket No. NHTSA–2023–0022–61952, at 8.

[820] The survey data collected by Consumer Reports on consumers' willigness to pay is invalauble, but taking that survey data and extrapolating about its potential impacts on fleet turnover is too inferential for the agency's current rulemaking.

[821] Consumer Reports, Docket No. NHTSA–2023–0022–61098, at 18.

[822] *See* Office of Management and Budget. 2023. Circular A–4. General Issues, 4. Developing an Analytic Baseline. Available at: *https://www.whitehouse.gov/wp-content/uploads/2023/11/CircularA-4.pdf.* (Accessed: Apr. 4, 2024).

This final rule includes a No-Action Alternative for passenger cars and light trucks and a No-Action alternative for HDPUVs, both described below; five “action alternatives” for passenger cars and light trucks; and four action alternatives for HDPUVs. Within both the set of alternatives that apply to passenger cars and light trucks and the set of alternatives that apply to HDPUVs, one alternative is identified as the “Preferred Alternative,” which is NEPA parlance. In some places the Preferred Alternative may also be referred to as the “standards” or “final standards,” but NHTSA intends “standards” and “Preferred Alternative” to be used interchangeably for purposes of this final rule. NHTSA believes the range of No-Action and action alternatives for each set of standards appropriately comports with CEQ's directive that “agencies shall . . . limit their consideration to a reasonable number of alternatives.”[823]

The different regulatory alternatives for passenger cars and light trucks are defined in terms of percent-changes in CAFE stringency from year to year. Readers should recognize that those year-over-year changes in stringency are *not* measured in terms of mile per gallon differences (as in, 1 percent more stringent than 30 mpg in one year equals 30.3 mpg in the following year), but rather in terms of shifts in the *footprint functions* that form the basis for the *actual* CAFE standards (as in, on a gallon per mile basis, the CAFE standards change by a given percentage from one model year to the next).[824]

For PCs, consistent with prior rulemakings, NHTSA is defining final fuel economy targets as shown in Equation IV–1.

$$\mathrm{TARGET}_{FE} = \frac{1}{\mathrm{MIN}\left[\mathrm{MAX}\left(c \times \mathrm{FOOTPRINT} + d, \frac{1}{a}\right), \frac{1}{b}\right]}$$

Equation IV-1: Passenger Car Fuel Economy Footprint Target Curve

Where:

TARGET_{FE} is the fuel economy target (in mpg) applicable to a specific vehicle model type with a unique footprint combination,
a is a minimum fuel economy target (in mpg),
b is a maximum fuel economy target (in mpg),
c is the slope (in gallons per mile per square foot, or gpm per square foot), of a line relating fuel consumption (the inverse of fuel economy) to footprint, and
d is an intercept (in gpm) of the same line.

Here, MIN and MAX are functions that take the minimum and maximum values, respectively, of the set of included values. For example, MIN[40, 35] = 35 and MAX(40, 25) = 40, such that MIN[MAX(40, 25), 35] = 35.

The resultant functional form is reflected in graphs displaying the passenger car target function in each model year for each regulatory alternative in Sections IV.B.1 and IV.B.3.

For LTs, also consistent with prior rulemakings, NHTSA is defining fuel economy targets as shown in Equation IV–2.

Equation IV-2: Light Truck Fuel Economy Footprint Target Curve

$$\mathrm{TARGET}_{FE} = \mathrm{MAX}\left(\frac{1}{\mathrm{MIN}\left[\mathrm{MAX}\left(c \times \mathrm{FOOTPRINT} + d, \frac{1}{a}\right), \frac{1}{b}\right]}, \frac{1}{\mathrm{MIN}\left[\mathrm{MAX}\left(g \times \mathrm{FOOTPRINT} + h, \frac{1}{e}\right), \frac{1}{f}\right]}\right)$$

Where:

TARGET_{FE} is the fuel economy target (in mpg) applicable to a specific vehicle model type with a unique footprint combination,
a, b, c, and d are as for PCs, but taking values specific to LTs,
e is a second minimum fuel economy target (in mpg),
f is a second maximum fuel economy target (in mpg),
g is the slope (in gpm per square foot) of a second line relating fuel consumption (the inverse of fuel economy) to footprint), and
h is an intercept (in gpm) of the same second line.

NHTSA is defining HDPUV fuel efficiency targets as shown in Equation IV–3:

$$\text{Sub configuration Target Standard (gallons per 100 miles)} = [c \times (WF)] + d$$

Equation IV-3: HDPUV Fuel Efficiency Work Factor Target Curve

Where:

c is the slope of the gasoline, CNG, Strong Hybrid, and PHEV work factor target curve in gal/100 mile per WF
For diesel engines, BEVs and FCEVs, c will be replaced with e
d is the gasoline CNG, Strong Hybrid, and PHEV minimum fuel consumption work factor target curve value in gal/100 mile

For diesel engines, BEVs and FCEVs, d will be replaced with f

WF = Work Factor = [0.75 × (Payload Capacity + Xwd)] + [0.25 × Towing Capacity]

Where:

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[823] 40 CFR 1502.14(f).

[824] The PC, LT, and HDPUV target curve function coefficients are defined in Equation IV–1, Equation IV–2, and Equation IV–3, respectively. See Final TSD Chapter 1.2.1 for a complete discussion about the footprint and work factor curve functions and how they are calculated.

Xwd = 4wd adjustment = 500 lbs. if the vehicle group is equipped with 4wd and all-wheel drive (AWD), otherwise equals 0 lbs. for 2wd
Payload Capacity = GVWR (lbs.) − Curb Weight (lbs.) (for each vehicle group)
Towing Capacity = GCWR (lbs.) − GVWR (lbs.) (for each vehicle group)

In a departure from recent CAFE rulemaking trends, for this final rule, we have applied different rates of increase to the passenger car and the light truck fleets in different model years. For the Preferred Alternative, rather than have both fleets increase their respective standards at the same rate, passenger car standards will increase at a steady rate year over year, while light truck standards will not increase for a few years before beginning to rise again at the passenger car rate. Several action alternatives evaluated for this final rule have passenger car fleet rates-of-increase of fuel economy that are different from the rates-of-increase of fuel economy for the light truck fleet, while the Preferred Alternative has the same rate of increase for passenger cars and light trucks for three out of the five model years. NHTSA has discretion, by law, to set CAFE standards that increase at different rates for cars and trucks, because NHTSA must set maximum feasible CAFE standards separately for cars and trucks.[825]

For HDPUVs, the different regulatory alternatives are also defined in terms of percent-increases in stringency from year to year, but in terms of fuel consumption reductions rather than fuel economy increases, so that increasing stringency appears to result in standards going *down* (representing a direct reduction in fuel consumed) over time rather than *up*. Also, unlike for the passenger car and light truck standards, because HDPUV standards are in fuel consumption space, year-over-year percent changes actually do represent gallon/mile differences across the work-factor range. For the Preferred Alternative, the stringency increases at one fixed percentage rate in each the first three model years, and a different fixed percentage rate in each of the remaining three model years in the rulemaking time frame. Under the other action alternatives, the stringency changes at the same percentage rate in each model year in the rulemaking time frame. One action alternative is less stringent than the Preferred Alternative for HDPUVs, and two action alternatives are more stringent.

B. Regulatory Alternatives Considered

The regulatory alternatives considered by the agency in this final rule are presented here as the percent-changes-per-year that they represent. The sections that follow will present the alternatives as the literal coefficients that define standards curves increasing at the given percentage rates.

Table IV-1: Regulatory Alternatives Under Consideration for MYs 2027-2031 Passenger Cars and Light Trucks

Name of Alternative	Passenger Car Stringency Increases, Year-Over-Year	Light Truck Stringency Increases, Year-Over-Year
No-Action Alternative	N/A	N/A
Alternative PC1LT3	1%	3%
Alternative PC2LT002 (Preferred Alternative)	2%	0% MYs 2027-28 2% MYs 2029-31
Alternative PC2LT4	2%	4%
Alternative PC3LT5	3%	5%
Alternative PC6LT8	6%	8%

Table IV-2: Regulatory Alternatives Under Consideration for MYs 2030-2035 HDPUVs

Name of Alternative	HDPUV Stringency Increases, Year-Over-Year
No-Action Alternative	N/A
Alternative HDPUV4	4%
Alternative HDPUV108 (Preferred Alternative)	10% MYs 2030-32 8% MYs 2033-35
Alternative HDPUV10	10%
Alternative HDPUV14	14%

A variety of factors will be at play simultaneously as manufacturers seek to comply with the final standards that NHTSA is promulgating. NHTSA, EPA, and CARB will all be regulating simultaneously; manufacturers will be

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[825] *See, e.g.,* the 2012 final rule establishing CAFE standards for model years 2017 and beyond, in which rates of stringency increase for passenger cars and light trucks were different. 77 FR 62623, 62638–39 (Oct. 15, 2012).

responding to those regulations as well as to foreseeable shifts in market demand during the rulemaking time frame (both due to cost/price changes for different types of vehicles over time, fuel price changes, and the recently-passed tax credits for BEVs and PHEVs). Many costs and benefits that will accrue as a result of manufacturer actions during the rulemaking time frame will be occurring for reasons other than CAFE standards, and NHTSA believes it is important to try to reflect many of those factors in order to present a more accurate picture of the effects of different potential CAFE and HDPUV standards to decision-makers and to the public. Because the EPA and NHTSA programs were developed in coordination jointly, and stringency decisions were made in coordination, NHTSA did not incorporate EPA's only recently-finalized CO_2 standards as part of the analytical reference baseline for the main analysis. The fact that EPA finalized its rule before NHTSA is an artifact of circumstance only.

The following sections define each regulatory alternative, including the No-Action Alternative, for each program, and explain their derivation.

1. Reference Baseline/No-Action Alternative

As with the 2022 final rule, our No-Action Alternative (also referred to as the reference baseline) is fairly nuanced. In this analysis, the reference No-Action Alternative assumes:

- The existing (through model year 2026) national CAFE and GHG standards are met, and that the CAFE and GHG standards for model year 2026 finalized in 2022 continue in perpetuity.[826]
- Manufacturers who committed to the California Framework Agreements met their contractual obligations for model year 2022.
- The HDPUV model year 2027 standards finalized in the NHTSA/EPA Phase 2 program continue in perpetuity.
- Manufacturers will comply with the Advanced Clean Trucks (ACT) program that California and other states intend to implement through 2035.
- Manufacturers will, regardless of the existence or non-existence of a legal requirement, produce additional electric vehicles consistent with the levels that would be required under the ZEV/Advanced Clean Cars II program, if it were to be granted a Clean Air Act preemption waiver.
- Manufacturers will make production decisions in response to estimated market demand for fuel economy or fuel efficiency, considering estimated fuel prices, estimated product development cadence, the estimated availability, applicability, cost, and effectiveness of fuel-saving technologies, and available tax credits.

NHTSA continues to believe that to properly estimate fuel economies/efficiencies (and achieved CO_2 emissions) in the No-Action Alternative, it is necessary to simulate all of these legal requirements, additional deployment plans of automakers, and other influences affecting automakers and vehicle design simultaneously.[827] Consequently, the CAFE Model evaluates each requirement in each model year, for each manufacturer/fleet. Differences among fleets and compliance provisions often create over-compliance in one program, even if a manufacturer is able to exactly comply (or under-comply) in another program. This is similar to how manufacturers approach the question of concurrent compliance in the real world—when faced with multiple regulatory programs, the most cost-effective path may be to focus efforts on meeting one or two sets of requirements, even if that results in ''more effort'' than would be necessary for another set of requirements, in order to ensure that all regulatory obligations are met. We elaborate on those model capabilities below. Generally speaking, the model treats each manufacturer as applying the following logic when making technology decisions, both for simulating passenger car and light truck compliance, and HDPUV compliance, with a given regulatory alternative:

1. What do I need to carry over from last year?
2. What should I apply more widely in order to continue sharing (of, *e.g.,* engines) across different vehicle models?
3. What new BEVs do I need to build in order to satisfy the various state ZEV programs and voluntary deployment of electric vehicles consistent with ACC II?
4. What further technology, if any, could I apply that would enable buyers to recoup additional costs within 30 months after buying new vehicles?
5. What additional technology, if any, should I apply to respond to potential new CAFE and CO_2 standards for PCs and LTs, or to potential new HDPUV standards?

Additionally, within the context of 4 and 5, the CAFE Model may consider, as appropriate and allowed by statutory restrictions on technology application for a given model year, the applicability of recently-passed tax credits for battery-based vehicle technologies, which improve the attractiveness of those technologies to consumers and thus the model's likelihood of choosing them as part of a compliance solution. The model can also apply over-compliance credits if applicable and not legally prohibited. The CAFE Model simulates all of these simultaneously. As mentioned above, this means that when manufacturers make production decisions in response to actions or influences other than CAFE or HDPUV standards, those costs and benefits are not attributable to possible future CAFE or HDPUV standards. This approach allows the analysis to isolate the effects of the decision being made on the appropriate CAFE standards, as opposed to the effects of many things that will be occurring simultaneously.

To account for the existing CAFE standards finalized in model year 2026 for passenger cars and light trucks, the No-Action Alternative includes the following coefficients defining those standards, which (for purposes of this analysis) are assumed to persist without change in subsequent model years:

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[826] NHTSA recognizes EPA published their Multi-Pollutant Emissions Standards For Model Years 2027 and Later Light-Duty and Medium-Duty Vehicles rule before this final rule is published, however, EPA's newest standards were not included in the baseline analysis, as the agencies developed their respective 27+ standards jointly.

[827] To be clear, this is for purposes of properly estimating the *No-Action* Alternative, which represents what NHTSA believes is likely to happen in the world in the *absence* of future NHTSA regulatory action. NHTSA does not attempt to simulate further application of BEVs, for example, in determining amongst the *action* alternatives for passenger cars and light trucks which one would be maximum feasible, because the statute prohibits NHTSA from considering the fuel economy of BEVs in determining maximum feasible CAFE standards.

Table IV-3: Passenger Car CAFE Target Function Coefficients for No-Action Alternative[828]

	2027	2028	2029	2030	2031	2032 (augural)
a (mpg)	66.95	66.95	66.95	66.95	66.95	66.95
b (mpg)	50.09	50.09	50.09	50.09	50.09	50.09
c (gpm per s.f)	0.00033512	0.00033512	0.00033512	0.00033512	0.00033512	0.00033512
d (gpm)	0.00119613	0.00119613	0.00119613	0.00119613	0.00119613	0.00119613

Table IV-4: Light Truck CAFE Target Function Coefficients for No-Action Alternative[829]

	2027	2028	2029	2030	2031	2032 (augural)
a (mpg)	53.73	53.73	53.73	53.73	53.73	53.73
b (mpg)	32.30	32.30	32.30	32.30	32.30	32.30
c (gpm per s.f)	0.00037418	0.00037418	0.00037418	0.00037418	0.00037418	0.00037418
d (gpm)	0.00327158	0.00327158	0.00327158	0.00327158	0.00327158	0.00327158

These coefficients are used to create the graphic below, where the x-axis represents vehicle footprint and the y-axis represents fuel economy, showing that in ''CAFE space,'' targets are higher in fuel economy for smaller footprint vehicles and lower for larger footprint vehicles.

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[828] The PC, LT, and HDPUV target curve function coefficients are defined in Equation IV–1, Equation IV–2, and Equation IV–3, respectively. See Final TSD Chapter 1.2.1 for a complete discussion about the footprint and work factor curve functions and how they are calculated.

[829] The PC, LT, and HDPUV target curve function coefficients are defined in Equations IV–1, IV–2, and IV–3, respectively. See Final TSD Chapter 1.2.1 for a complete discussion about the footprint and work factor curve functions and how they are calculated.

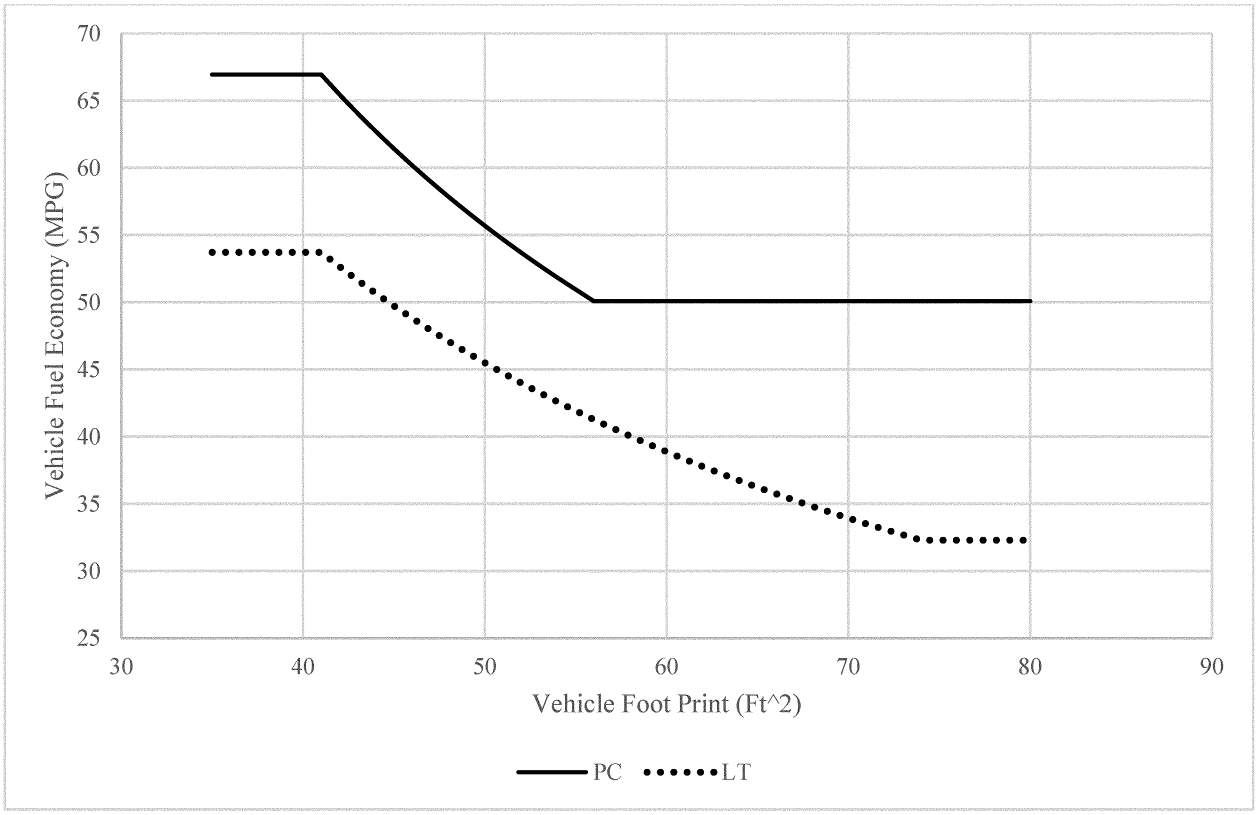

Figure IV-1: No-Action Alternative, Passenger Car and Light Truck Fuel Economy, Target Curves

Additionally, EPCA, as amended by EISA, requires that any manufacturer's domestically-manufactured passenger car fleet must meet the greater of either 27.5 mpg on average, or 92 percent of the average fuel economy projected by the Secretary for the combined domestic and non-domestic passenger automobile fleets manufactured for sale in the United States by all manufacturers in the model year. NHTSA retains the 1.9 percent offset to the Minimum Domestic Passenger Car Standard (MDPCS), first used in the 2020 final rule, to account for recent projection errors as part of estimating the total passenger car fleet fuel economy, and used in rulemakings since.[830] [831] The projection shall be published in the **Federal Register** when the standard for that model year is promulgated in accordance with 49 U.S.C. 32902(b).[832] [833] For purposes of the No-Action Alternative, the MDPCS is as it was established in the 2022 final rule for model year 2026, as shown in Table IV–5 below:

Table IV-5: No-Action Alternative – Minimum Domestic Passenger Car Standard (MDPCS) (MPG)

2027	2028	2029	2030	2031	2032 (augural)
53.5	53.5	53.5	53.5	53.5	53.5

To account for the HDPUV standards finalized in the Phase 2 rule, the No-Action Alternative for HDPUVs includes the following coefficients defining those standards, which (for purposes of this analysis) are assumed to persist without change in subsequent model years:

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[830] Section VI.A.2 (titled ''Separate Standards for Passenger Cars, Light Trucks, and Heavy-Duty Pickups and Vans, and Minimum Standards for Domestic Passenger Cars'') discusses the basis for the offset.

[831] 87 FR 25710 (May 2, 2022).

[832] 49 U.S.C. 32902(b)(4).

[833] The offset will be applied to the final regulation numbers, but was not used in this analysis. The values for the MDPCS for the action alternatives are nonadjusted values.

Table IV-6: HDPUV CI Vehicle Fuel Efficiency Target Function Coefficients for No-Action Alternative[834]

	2030	2031	2032	2033	2034	2035
e (gal/100 miles per WF)	0.00034180	0.00034180	0.00034180	0.00034180	0.00034180	0.00034180
f (gal/100 miles per WF)	2.633	2.633	2.633	2.633	2.633	2.633

Table IV-7: HDPUV SI Vehicle Fuel Efficiency Target Function Coefficients for No-Action Alternative[835]

	2030	2031	2032	2033	2034	2035
c (gal/100 miles per WF)	0.00041520	0.00041520	0.00041520	0.00041520	0.00041520	0.00041520
d (gal/100 miles per WF)	3.196	3.196	3.196	3.196	3.196	3.196

These equations are represented graphically below:

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[834] The PC, LT, and HDPUV target curve function coefficients are defined in Equation IV–1, Equation IV–2, and Equation IV–3, respectively. See Final TSD Chapter 1.2.1 for a complete discussion about the footprint and work factor curve functions and how they are calculated.

[835] The PC, LT, and HDPUV target curve function coefficients are defined in Equation IV–1, Equation IV–2, and Equation IV–3, respectively. See Final TSD Chapter 1.2.1 for a complete discussion about the footprint and work factor curve functions and how they are calculated.

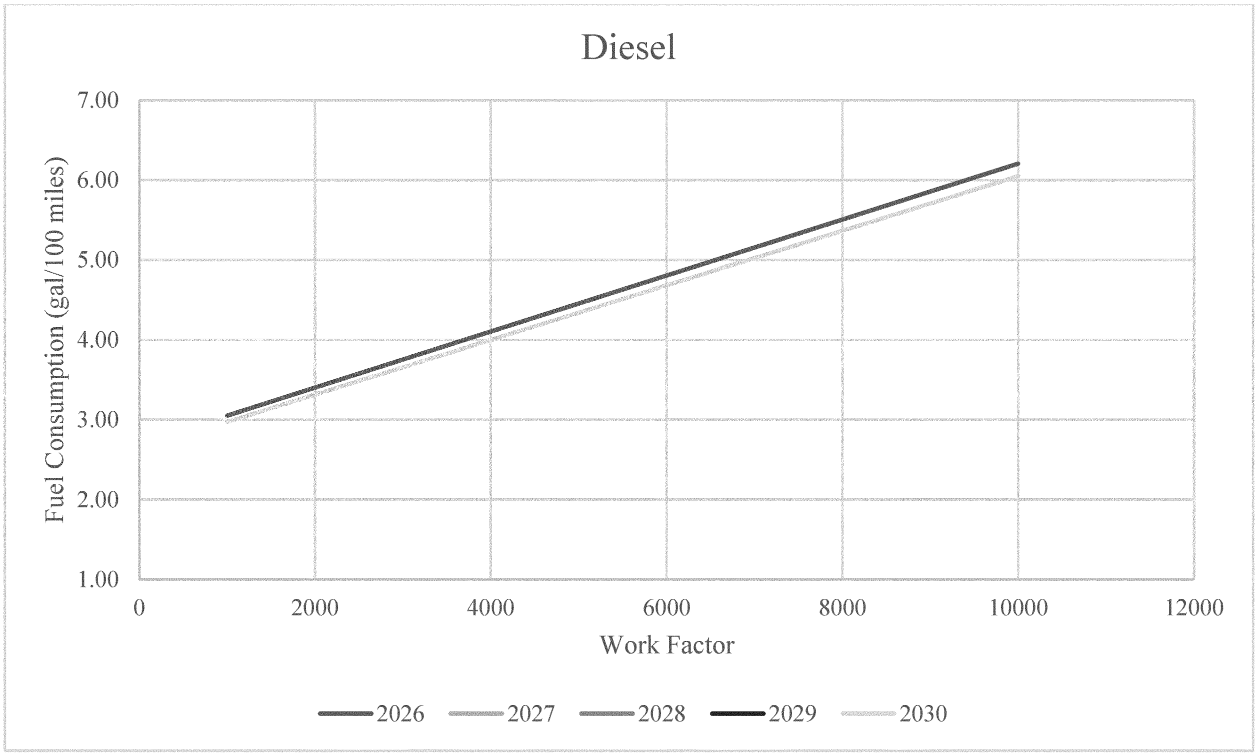

Figure IV-2: No-Action Alternative, HDPUV – CI, BEV, and FCEV Vehicles, Target Curves

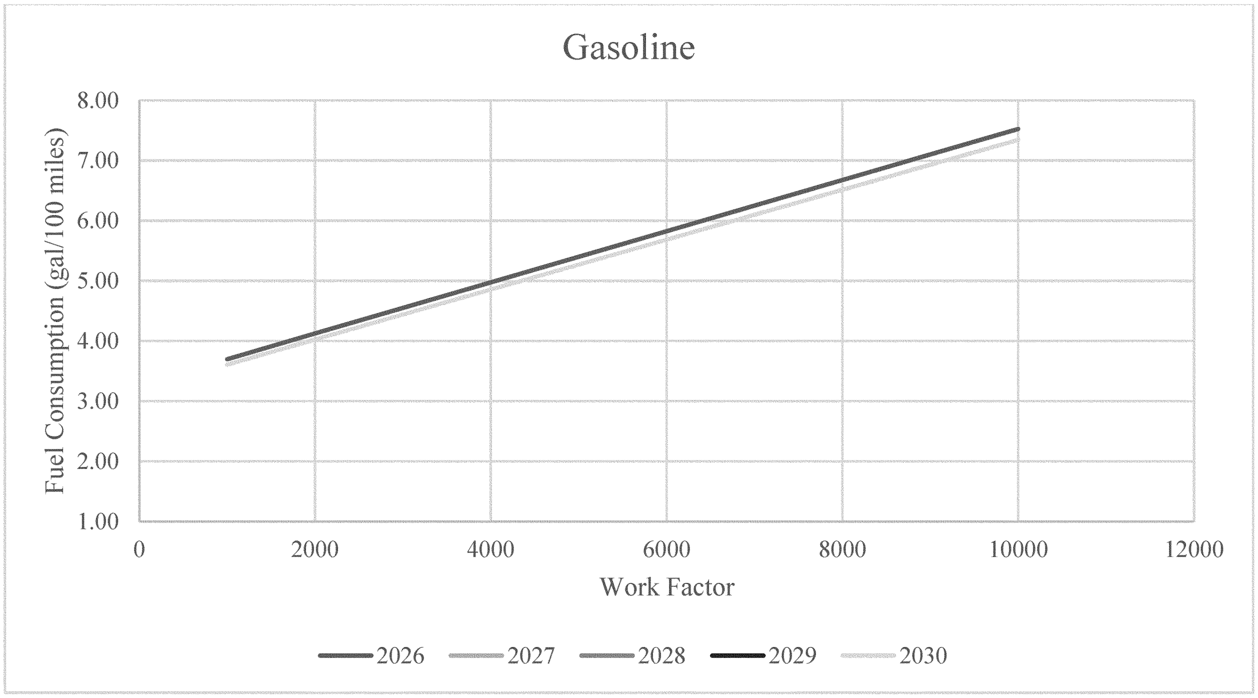

Figure IV-3: No-Action Alternative, HDPUV – SI, CNG, SHEV and PHEV Vehicles, Target Curves

As the reference baseline scenario, the No-Action Alternative also includes the following additional actions that NHTSA believes will occur in the absence of further regulatory action by NHTSA:

To account for the existing national GHG emissions standards, the No-Action Alternative for passenger cars and light trucks includes the following coefficients defining the GHG standards set by EPA in 2022 for model year 2026, which (for purposes of this analysis) are assumed to persist without change in subsequent model years:

Table IV-8: Passenger Car CO2 Target Function Coefficients for No-Action Alternative

	2027	2028	2029	2030	2031	2032
a (g/mi)	114.3	114.3	114.3	114.3	114.3	114.3
b (g/mi)	160.9	160.9	160.9	160.9	160.9	160.9
c (g/mi per s.f)	3.11	3.11	3.11	3.11	3.11	3.11
d (g/mi)	-13.10	-13.10	-13.10	-13.10	-13.10	-13.10
e (s.f.)	41.0	41.0	41.0	41.0	41.0	41.0
f (s.f.)	56.0	56.0	56.0	56.0	56.0	56.0

Table IV-9: Light Truck CO2 Target Function Coefficients for No-Action Alternative

	2027	2028	2029	2030	2031	2032
a (g/mi)	141.8	141.8	141.8	141.8	141.8	141.8
b (g/mi)	254.4	254.4	254.4	254.4	254.4	254.4
c (g/mi per s.f)	3.41	3.41	3.41	3.41	3.41	3.41
d (g/mi)	1.90	1.90	1.90	1.90	1.90	1.90
e (s.f.)	41.0	41.0	41.0	41.0	41.0	41.0
f (s.f.)	74.0	74.0	74.0	74.0	74.0	74.0

Coefficients *a, b, c, d, e,* and *f* define the model year 2026 Federal CO_2 standards for passenger cars and light trucks, respectively, in Table IV–8 and Table IV–9 above. Analogous to coefficients defining CAFE standards, coefficients *a* and *b* specify minimum and maximum CO_2 targets in each model year. Coefficients *c* and *d* specify the slope and intercept of the linear portion of the CO_2 target function, and coefficients *e* and *f* bound the region within which CO_2 targets are defined by this linear form.

To account for the NHTSA/EPA Phase 2 national GHG emission standards, the No-Action Alternative for HDPUVs includes the following coefficients defining the WF based standards set by EPA for model year 2027 and beyond. The four-wheel drive coefficient is maintained at 500 (coefficient 'a') and the weighting multiplier coefficient is maintained at 0.75 (coefficient 'b'). The CI and SI coefficients are in the tables below:

Table III-10: HDPUV CI Vehicle CO_2 Target Function Coefficients for No-Action Alternative

	2027 and Later
e	0.0348
f	268

Table III-11: HDPUV SI Vehicle CO_2 Target Function Coefficients for All Alternatives

	2027 and Later
c	0.0369
d	284

Coefficients *c, d, e,* and *f* define the existing model year 2027 and beyond CO_2 standards from Phase 2 rule for HDPUVs, in Table III–10 and Table III–11 above. The coefficients are linear work-factor based function with c and d representing gasoline, CNG vehicles, SHEVs and PHEVS and *e* and *f* representing diesels, BEVS and FCEVs. For this rulemaking, this is identical to the NHTSA's fuel efficiency standards No Action alternative.

The reference baseline No-Action Alternative also includes NHTSA's estimates of ways that each manufacturer could introduce new PHEVs and BEVs in response to state ZEV programs and additional production of PHEVs and BEVs that manufacturers have indicated they will undertake consistent with ACC II, regardless of whether it becomes a legal requirement.[836] To account for manufacturers' expected compliance with the ACC I and ACT programs and additional deployment of electric vehicles consistent with ACC II, NHTSA has included the main provisions of the ACC, ACC II, (as currently submitted to EPA), and ACT programs in the CAFE Model's analysis. Incorporating these programs into the model includes converting vehicles that have been identified as potential ZEV candidates into battery-electric vehicles (BEVs) and taking into account PHEVs that meet the ZEV PHEV credit requirements so that a manufacturer's fleet meets the calculated ZEV credit requirements or anticipated voluntary compliance. The CAFE Model makes manufacturer fleets consistent with ACC I, ACC II (as currently submitted to EPA), and ACT first in the reference baseline, then solves for the technology pathway used to meet increasing ZEV penetration levels described by the state programs. Chapter 2.3 of the Final TSD discusses, in detail, how NHTSA developed these estimates.

Several stakeholders commented in support of NHTSA's inclusion of state ZEV programs and assumptions regarding other electric vehicles that will be deployed in the absence of legal requirements in the reference baseline.[837] The States and Cities, for example, commented that ''[g]iven NHTSA's duty to project a No-Action baseline that accounts for sharply growing zero emission vehicle sales, modeling compliance with California's Advanced Clean Cars I (''ACCI''), Advanced Clean Cars II (''ACCII''), and Advanced Clean Trucks (''ACT'') regulations is a reasonable methodology to do so, at least in the event that California is granted its requested waiver for ACCII and ACCII thus becomes enforceable.'' [838] Similarly, the Joint NGOs commented that ''consistent with EPCA's language, history, and legislative intent, NHTSA models an accurate, real-world 'no action' baseline for the rulemaking, a task that requires a rational accounting of the real-world BEVs and PHEVs projected to exist in the absence of the CAFE standards NHTSA is considering. . . . NHTSA has done so here.'' [839]

Some stakeholders commented about uncertainties that they believe could impact the reference baseline. For example, Kia commented that ''[w]hile automakers will plan to comply with the regulations, there is great uncertainty as to whether automakers have the capacity to do so, whether the California ZEV mandate will remain as currently written through 2035, whether states that have adopted it will remain in the program, and whether California will be granted a waiver.'' [840]

Other stakeholders commented in explicit opposition to modeling state ZEV programs in the reference baseline.[841] Stakeholders asserted that NHTSA could not account for state ZEV programs in the light-duty standards reference baseline because of EPCA/EISA's statutory prohibition on considering electric vehicle fuel economy in 49 U.S.C. 32902(h). Several of these commenters objected in particular to NHTSA's use of OMB Circular A–4 to guide the development of the light-duty regulatory reference baseline, as they believe that Circular A–4 cannot ''trump a clear statutory requirement,'' referring to 49 U.S.C. 32902(h).[842] Stakeholders also commented that state ZEV programs should not be included in the reference baseline because they are preempted by various federal laws,[843] and/or because EPA has not yet granted a waiver of preemption to California for the ACC II program.[844] Commenters opposing the inclusion of state ZEV programs in the reference baseline also alleged that it was a backdoor way to establish an EV mandate when setting CAFE standards.[845] [846]

Toyota did not explicitly object to NHTSA's consideration of state ZEV

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[836] NHTSA interprets EPCA/EISA as allowing consideration of BEVs and PHEVs built in response to state ZEV programs or voluntary deployed by automakers independent of NHTSA's standards as part of the analytical baseline because (1) 49 U.S.C. 32902(h) clearly applies to the ''maximum feasible'' determination made under 49 U.S.C. 32902(f), which is a determination *between* regulatory alternatives, and the baseline is simply the backdrop against which that determination is made, and (2) NHTSA continues to believe that it is arbitrary to interpret 32902(h) as requiring NHTSA to pretend that BEVs and PHEVs clearly built for non-CAFE-compliance reasons do not exist, because doing so would be unrealistic and would bias NHTSA's analytical results by inaccurately attributing costs and benefits to future potential CAFE standards that will not accrue as a result of those standards in real life.

[837] States and Cities, Docket No. NHTSA–2023–0022–61904, Attachment 2, at 40; Joint NGOs, Docket No. NHTSA–2023–0022–61944, Attachment 2, at 56–57; ALA, Docket No. NHTSA–2023–0022–60091, at 2–3; Tesla, Docket No. NHTSA–2023–0022–60093, at 7.

[838] States and Cities, Docket No. NHTSA–2023–0022–61904, Attachment 2, at 40.

[839] Joint NGOs, Docket No. NHTSA–2023–0022–61944, Attachment 2, at 56–57.

[840] Kia, Docket No. NHTSA–2023–0022–58542–A1, at 4–5.

[841] Growth Energy, Docket No. NHTSA–2023–0022–61555, at 1; KCGA, Docket No. NHTSA–2023–0022–59007, at 2; RFA, NCGA, and NFU, Docket No. NHTSA–2023–0022–57625; NCB, Docket No. NHTSA–2023–0022–53876; CEA, Docket No. NHTSA–2023–0022–61918, at 6; Corn Growers Associations, Docket No. NHTSA–2023–0022–62242, at 4; ACE, Docket No. NHTSA–2023–0022–60683; The Alliance, Docket No. NHTSA–2023–0022–60652, Attachment 3, at 8–13; Toyota, Docket No. NHTSA–2023–0022–61131, at 2, 23; AmFree, Docket No. NHTSA–2023–0022–62353, at 4; AFPM, Docket No. NHTSA–2023–0022–61911, Attachment 2, at 23; Stellantis, Docket No. NHTSA–2023–0022–61107, at 9; POET, Docket No. NHTSA–2023–0022–61561, at 13–16.

[842] *E.g.,* The Alliance, Docket No. NHTSA–2023–0022–60652, Attachment 0, at 2.

[843] RFA, NCGA, and NFU, Docket No. NHTSA–2023–0022–57625; CEA, Docket No. NHTSA–2023–0022–61918, at 9; Corn Growers Associations, Docket No. NHTSA–2023–0022–62242, at 6–8; AFPM, Docket No. NHTSA–2023–0022–61911, Attachment 2, at 22.

[844] Valero, Docket No. NHTSA–2023–0022–58547, at 5; Hyundai, Docket No. NHTSA–2023–0022–51701, at 5; Nissan, Docket No. NHTSA–2023–0022–60684, at 4; The Alliance, Docket No. NHTSA–2023–0022–60652, Attachment 3, at 8–13; AFPM, Docket No. NHTSA–2023–0022–61911, Attachment 2, at 23; Corn Growers Associations, Docket No. NHTSA–2023–0022–62242, at 8.

[845] Valero, Docket No. NHTSA–2023–0022–58547, Attachments A, B, C, and D. Valero gave as an example vehicle models that were flagged in the analysis fleet as BEV ''clones'' turning into BEVs from model year 2022 to model year 2027 and later. However NHTSA has confirmed that is exactly how our modeling of the ZEV program was intended to operate. NHTSA directs Valero to TSD Chapter 2.5, which describes when ZEV clones are created and when sales volume is assigned to those clones for ZEV program compliance, and the CAFE Model Documentation, which describes how the CAFE Model implements restrictions surrounding BEV technology unrelated to ZEV modeling.

[846] *See, e.g.,* CEA, Docket No. NHTSA–2023–0022–61918, at 12. CEA stated that ''NHTSA's baseline is a federal 'insurance' policy in the event that state mandates are repealed or struck down by the courts—a federal regulatory 'horcrux' that'll ensure the continued survival of these state laws even if they are killed elsewhere.'' It should be noted that while a horcrux and this commenter's implied definition of a ''federal 'insurance' policy'' would function similarly in their ability to preserve and protect, the creation process for each would be markedly dissimilar. Moreover, even if NHTSA's baseline was a ''horcrux,'' the agency would liken it to the horcrux in Harry Potter himself: It was created organically as a product of the circumstances, and even after attempts to be struck down, the Advanced Clean Car program does still live. *Ohio* v. *E.P.A.,* No. 22–1081 (D.C. Cir. Apr. 9, 2024).

regulatory programs in the reference baseline but stated that ''NHTSA should consider the impact of the EVs stemming from both the ZEV Mandate and the GHG Program, but then use that knowledge to establish economically practicable CAFE standards for the remining ICEs in the U.S. fleet, thereby simultaneous[sic] satisfying 49 U.S.C. 32902(h). For example, if 45 percent of a projected 17 million vehicle fleet in 2030 model year will be electrified due to other government programs, CAFE standards would be set for the remaining 9.4 million ICE and hybrid vehicles.'' [847]

Several stakeholders also commented about specific assumptions used in the ZEV modeling such as the number of states signed on to the program, how some compliance obligations should be assumed to be met through credits, and assumptions around PHEV credit values; those comments are addressed in Section III.C.5, above.

NHTSA agrees with commenters that the agency has a duty to model a reference baseline that includes increasing zero emission vehicle sales in response to state standards, and that the agency's methodology for doing so is consistent with EPCA's language, history, and legislative intent. NHTSA continues to believe that it is appropriate for the reference baseline to reflect legal obligations other than CAFE standards that automakers will be meeting and additional non-regulatory deployment of electric vehicles during this time period so that the regulatory analysis can identify the distinct effects of the CAFE standards. Information provided by California continues to show there has been industry compliance with the ZEV standards,[848] which provides further confirmation that manufacturers will meet legally-binding state standards. This is also confirmed by manufacturers' stated intent to deploy electric vehicles consistent with what would be required under ACC II, regardless of whether it becomes a binding legal obligation, as discussed in more detail below.

In response to comments opposing the inclusion of state ZEV programs in the reference baseline because doing so conflicts with 49 U.S.C. 32902(h), NHTSA maintains that it is perfectly possible to give meaningful effect to the 49 U.S.C. 32902(h) prohibition by not allowing the CAFE Model to rely on ZEV (or other dedicated alternative fuel) technology during the rulemaking time frame, while still acknowledging the clear reality that the state ZEV programs exist, and manufacturers are complying with them, just like the agency acknowledges that electric vehicles exist in the fleet independent of the ZEV program. Comments regarding whether including state ZEV programs in the reference baseline is consistent with 49 U.S.C. 32902(h) are discussed in more detail below in Section VI.A.5.a.(5), and in the final rule for model years 2024–2026 CAFE standards.[849] Regarding commenters' views that state ZEV programs are preempted, NHTSA addressed preemption in the agency's 2021 rulemaking, and further discussion is located in the NPRM and final rule for that rulemaking.[850] In that rulemaking, the agency expressed ''significant doubts as to the validity'' of preemption positions similar to those raised by commenters here.[851]

NHTSA also disagrees that including state ZEV programs in the reference baseline is a way to, according to commenters, ''bypass'' limitations in 49 U.S.C. 32902(h). ACC I is a relevant legal requirement that manufacturers must meet,[852] and as mentioned above, manufacturers are not just meeting those standards, they are exceeding them.[853] Further, manufacturers have indicated their intent to deploy electric vehicles consistent with what would be required under ACC II, regardless of whether it becomes a binding legal obligation. Vehicle manufacturers told NHTSA, in CBI conversations regarding planned vehicle product and technology investments, that they are complying with and plan to comply in the future with ZEV programs.[854] These conversations were later confirmed by manufacturers' subsequent public announcements, confirming both their support for California's programs and for meeting their own stated electrification goals, which are discussed in extensive detail below.

Kia, stating in their comments that ''automakers will plan to comply with the regulations,'' joins a list of OEMs that have established that they are planning technology decisions to comply with state ZEV program deployment levels: Stellantis in a recent agreement with California confirmed that they will explicitly comply with the ACC programs through 2030; [855] General Motors sent a letter to California Governor Gavin Newsom both recognizing California's authority under the Clean Air Act to set vehicle emissions standards and expressing its commitment to ''emissions reductions that are aligned with the California Air Resources Board's targets and . . . complying with California's regulations'',[856] and Ford, Volkswagen, BMW, Honda, and Volvo formed a group of five manufacturers that committed in 2020 to comply with ZEV program requirements and have since reiterated their support for California's programs in a lengthy declaration to the D.C. Circuit Court of Appeals.[857] Not only have all three domestic automakers expressed support for California's standards, several other automakers have followed suit in explicitly expressing support for California's programs, as shown above.

Further, automakers have publicly signaled their commitment to the EV transition at levels that well exceed the 28 percent BEV market share in MY 2031 reflected in the baseline reference case. In August 2021, major automakers including GM, Ford, Stellantis, BMW, Honda, Volkswagen, and Volvo pledged their support to achieve 40 to 50 percent sales of electric vehicles by 2030.[858] These announcements are consistent with previous and ongoing corporate statements. Several manufacturers have announced plans to fully transition to electric vehicles, such as General

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[847] Toyota, Docket No. NHTSA–2023–0022–61131, at 24.

[848] California Air Resources Board, Annual ZEV Credits Disclosure Dashboard, available at *https://ww2.arb.ca.gov/applications/annual-zev-credits-disclosure-dashboard* (accessed April 12, 2024).

[849] 87 FR 25899–900 (May 2, 2022).

[850] CAFE Preemption. 86 FR 25,980 (May 12, 2021); 86 FR 74,236 (Dec. 29, 2021).

[851] *See* 86 FR 25,980, 25,990.

[852] *Ohio* v. *E.P.A.,* No. 22–1081 (D.C. Cir. Apr. 9, 2024).

[853] California Air Resources Board, Annual ZEV Credits Disclosure Dashboard, available at *https://ww2.arb.ca.gov/applications/annual-zev-credits-disclosure-dashboard* (accessed April 12, 2024).

[854] Docket ID NHTSA–2023–0022–0007, Docket Submission of Ex Parte Meetings Prior to Publication of the Corporate Average Fuel Economy Standards for Passenger Cars and Light Trucks for Model Years 2027–2032 and Fuel Efficiency Standards for Heavy-Duty Pickup Trucks and Vans for Model Years 2030–2035 Notice of Proposed Rulemaking.

[855] California Air Resources Board, California announces partnership with Stellantis to further emissions reductions (March 19, 2024), available at *https://ww2.arb.ca.gov/news/california-announces-partnership-stellantis-further-emissions-reductions.*

[856] Hayley Harding, GM to recognize California emissions standards, allowing state to buy its fleet vehicles, The Detroit News (Jan. 9, 2022), available at *https://www.detroitnews.com/story/business/autos/general-motors/2022/01/09/gm-recognizes-calif-emission-standards-opening-door-fleet-sales/9153355002/.*

[857] Initial Brief for Industry Respondent-Intervenors (Document #1985804, filed February 13, 2023) in *Ohio* v. *E.P.A.,* No. 22–1081 (D.C. Cir. Apr. 9, 2024); California Air Resources Board, Zero-Emission Vehicle Program, available at *https://ww2.arb.ca.gov/our-work/programs/zero-emission-vehicle-program/about.*

[858] The White House, ''Statements on the Biden Administration's Steps to Strengthen American Leadership on Clean Cars and Trucks,'' August 5, 2021. Accessed on October 19, 2021 at *https://www.whitehouse.gov/briefing-room/statements-releases/2021/08/05/statements-on-the-biden-administrations-steps-to-strengthen-american-leadership-on-clean-cars-and-trucks/.*

Motors ambition to shift its light-duty vehicles entirely to zero-emissions by 2035,[859] Volvo's plans to make only electric cars by 2030,[860] Mercedes plans to become ready to go all-electric by 2030 where possible,[861] and Honda's full electrification plan by 2040.[862] Other car makers have chosen incremental commitments to electrification that are still exceed the equivalent national EV market share reflected in the reference baseline, such as Ford's announcement that the company expects 40 percent of its global sales will be all-electric by 2030,[863] Volkswagen's expectation that half of its U.S. sales will be all-electric by 2030,[864] Subaru's global target to achieve 50 percent BEVs by 2030,[865] and Toyota's plans to introduce 30 BEV models by 2030.[866] In addition to Honda's fully-electric target in 2040, the company also expects 40 percent of North American sales to be fully electric by 2030, and 80 percent by 2035.[867]

The transition to electric vehicles is also taking place among heavy-duty pick-up trucks and vans, with much of the initial focus on last mile delivery vans. Several models of parcel delivery vans have already entered the market including GM's BrightDrop Zevo 400 and Zevo 600; and the Rivian EDV 500 and EDV 700.[868] [869] Commercial fleets have announced commitments to purchase zero emission delivery trucks and vans, including FedEx,[870] Amazon,[871] and Walmart.[872] Amazon reached 10,000 electric delivery vans operating in over 18,000 U.S. cities.[873]

These commitments provide further confirmation that automakers plan to deploy electric vehicles at the levels indicated in the reference baseline. They also provide further evidence that NHTSA's modeled reference baseline is a reasonable—yet, as discussed further below, likely conservative—representation of manufacturers' future product offerings. Nevertheless, NHTSA developed an alternative baseline that does not include ACC I or manufacturer deployment of electric vehicles that would be consistent with ACC II—and as discussed below, NHTSA determined that its final standards are reasonable as compared against this alternative baseline.

In response to Toyota's alternative approach to considering state ZEV programs in the analysis, not only does NHTSA not believe this approach would allow the agency to set maximum feasible standards, but NHTSA believes that the agency functionally already does what Toyota is describing. In addition, by converting vehicles to BEVs to comply with the ZEV program first, and then applying technology to the rest of the remaining fleet, NHTSA is setting a standard based only on the capability of the rest of the fleet to apply non-BEV technology.

Finally, in regards to including BEVs in the light-duty reference baseline, while NHTSA agrees that OMB Circular A–4 cannot trump a clear statutory requirement, NHTSA disagrees the agency's reference baseline does or attempts to do so. Nowhere does EPCA/EISA say that NHTSA should not consider the best available evidence in establishing the regulatory reference baseline for its CAFE rulemakings. As explained in Circular A–4, ''the benefits and costs of a regulation are generally measured against a no-action baseline: an analytically reasonable forecast of the way the world would look absent the regulatory action being assessed, including any expected changes to current conditions over time.'' [874] NHTSA makes clear that its interpretation of 49 U.S.C. 32902(h) restricts the agency's analytical options when analyzing what standards are maximum feasible, while being consistent with A–4's guidance about how best to construct the reference baseline. Thus, absent a clear indication to blind itself to important facts, NHTSA continues to believe that the best way to implement its duty to establish maximum feasible CAFE standards is to establish as realistic a reference baseline as possible, including, among other factors, the most likely composition of the fleet. This concept is discussed in more detail in Section VI.A.

In addition to their comments opposing the inclusion of ACC I and ACC II in the light duty reference baseline, Valero also commented opposing NHTSA's inclusion of the ACT program in the HDPUV reference baseline, for several reasons.[875] Regarding Valero's statutory arguments, we direct Valero to EPA's grant of the waiver of preemption for California's ACT program.[876] EPA made requisite findings under the Clean Air Act that the waiver should be granted and also grappled with several issues that commenters raised about the program. NHTSA defers to EPA's judgment there. Valero also took issue with the fact that all states that have adopted California's ACT program standards have adopted them on a different timeline than California, for example Massachusetts' program beings with model year 2025 and Vermont's program begins in model year 2026. NHTSA defers to EPA on what is an appropriate interpretation of 42 U.S.C. 7507 but believes the agency has appropriately modeled a most likely future scenario as a reference baseline for future years.

Separately, NHTSA can include a legal obligation in the reference baseline that ''has not yet begun implementation or demonstrated feasibility,'' contrary to Valero's assertions. First, regarding the program having ''not yet begun implementation'': a reference baseline is an ''analytically reasonable *forecast* of the way the world would look absent the regulatory action being assessed'' (emphasis added),[877] and the nature of

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[859] General Motors, ''General Motors, the Largest U.S. Automaker, Plans to be Carbon Neutral by 2040,'' Press Release, January 28, 2021.

[860] Volvo Car Group, ''Volvo Cars to be fully electric by 2030,'' Press Release, March 2, 2021.

[861] Mercedes-Benz, ''Mercedes-Benz prepares to go all-electric,'' Press Release, July 22, 2021.

[862] Honda News Room, ''Summary of Honda Global CEO Inaugural Press Conference,'' April 23, 2021. Accessed June 15, 2021 at https://global.honda/newsroom/news/2021/c210423eng.html.

[863] Ford Motor Company, ''Superior Value From EVs, Commercial Business, Connected Services is Strategic Focus of Today's 'Delivering Ford+' Capital Markets Day,'' Press Release, May 26, 2021.

[864] Volkswagen Newsroom, ''Strategy update at Volkswagen: The transformation to electromobility was only the beginning,'' March 5, 2021. Accessed June 15, 2021 at *https://www.volkswagen-newsroom.com/en/stories/strategy-update-at-volkswagen-the-transformation-to-electromobility-was-only-the-beginning-6875.*

[865] Subaru Corporation, ''Briefing on the New Management Policy,'' August 2, 2023. Accessed on December 5, 2023 at *https://www.subaru.co.jp/pdf/news-en/en2023_0802_1_2023-08-01-193334.pdf*

[866] Toyota Motor Corporation, ''Video: Media Briefing on Battery EV Strategies,'' Press Release, December 14, 2021. Accessed on December 14, 2021 at *https://global.toyota/en/newsroom/corporate/36428993.html.*

[867] Honda News Room, ''Summary of Honda Global CEO Inaugural Press Conference,'' April 23, 2021. Accessed June 15, 2021 at *https://global.honda/newsroom/news/2021/c210423eng.html.*

[868] *https://www.gobrightdrop.com/.*

[869] *https://rivian.com/fleet.*

[870] BrightDrop, ''BrightDrop Accelerates EV Production with First 150 Electric Delivery Vans Integrated into FedEx Fleet,'' Press Release, June 21, 2022.

[871] Amazon Corporation, ''Amazon's Custom Electric Delivery Vehicles from Rivian Start Rolling Out Across the U.S.,'' Press Release, July 21, 2022.

[872] Walmart, ''Walmart To Purchase 4,500 Canoo Electric Delivery Vehicles To Be Used for Last Mile Deliveries in Support of Its Growing eCommerce Business,'' Press Release, July 12, 2022.

[873] *https://www.axios.com/2023/10/17/amazon-rivian-electrification-10000-climate.*

[874] OMB Circular A–4, ''Regulatory Analysis'' Nov. 9, 2003, at 11. Note that Circular A–4 was recently updated; the initial version was in effect at the time of the proposal.

[875] Valero, Docket No. NHTSA–2023–0022–58547, Attachmend D, at 4.

[876] 88 FR 20688 (April 6, 2023).

[877] OMB Circular A–4, at 11. Some commenters in support of their arguments that NHTSA cannot consider state ZEV programs in the baseline have

the Clean Air Act waiver process is that EPA grants waivers for programs that will affect *future* model years.

Regarding the argument that the ACT program has not demonstrated feasibility, Chapter 2.5.1 of the TSD shows the ZEV sales percentage requirements for Class 2b and 3 trucks (the vehicles covered by the HDPUV standards included in this final rule) and in the near-term, model years 2024–2026, the requirements increase by just 3% per year, and then only by 5% per year in the model years after that. The HDPUV segment is also a fraction of the size of the light-duty segment, as discussed elsewhere in this preamble, but stakeholders have already identified portions of the HDPUV segment that are candidates for electrification. For example, a North American Council for Freight Efficiency (NACFE) study of electrification for vans and step vans found that ''fleets are aggressively expanding their purchases of electric vans and step vans after successful pilot programs.'' [878] Delivery vans are especially suited for electrification because range is typically not a major factor in urban delivery/e-commerce solutions, which in particular are spurring a rapid growth in the van and step van market segment.[879] In other words, the market seems to be heading in a direction to meet state HDPUV ZEV programs not solely because of the requirements, but also because the segment is ready for it. Valero's characterization of state ACT programs as ''the transition of a large and complex transportation system'' and a ''massive undertaking,'' is an inaccurate dramatization of the scale of the ACT program in relation to NHTSA's current analysis.

Like for the NPRM, NHTSA additionally ran the CAFE Model for the HDPUV analysis assuming the ACT program was not included in the reference baseline. In the RIA, Table 9–8 highlights the changes in technology penetration for the HDPUV No ZEV sensitivity. We see that by model year 2038, BEV penetration decreases by just 0.2% and mild hybrid penetration increases by 4.9% when compared to the reference baseline. Between 2022–2050 we also see net social benefits increase by $1.81b, gasoline consumption is reduced by 1 billion gallons, and regulatory costs per vehicle increase by $41. This happens for two reasons: BEVs are still a relatively cost-effective technology for compliance with increasing levels of standards, and all of the benefits captured by the ACT program in the reference baseline are now attributable to our HDPUV program in the alternative case. Removing the ACT program from the HDPUV reference baseline has little impact on the analysis and it alone does not lead us to change our preferred alternative.

The No-Action Alternative also includes NHTSA estimates of ways that manufacturers could take advantage of recently-passed tax credits for battery-based vehicle technologies. NHTSA explicitly models portions of three provisions of the IRA when simulating the behavior of manufacturers and consumers. The first is the Advanced Manufacturing Production Tax Credit (AMPC). The AMPC also includes a credit for the production of applicable minerals. This provision of the IRA provides a $35 per kWh tax credit for manufacturers of battery cells and an additional $10 per kWh for manufacturers of battery modules (all applicable to manufacture in the United States).[880] These credits, with the exception of the critical minerals credit, phase out 2030 to 2032. The agency also jointly modeled the Clean vehicle credit and the Credit for qualified commercial clean vehicles (CVCs),[881] which provides up to $7,500 toward the purchase of clean vehicles covered by this regulation.[882] [883] The AMPC and CVCs provide tax credits for light-duty and HDPUV PHEVs, BEVs, and FCVs. Chapter 2.3 in the TSD discusses, in detail, how NHTSA has modeled these tax credits.

Stakeholders commented that NHTSA both underestimated and overestimated the effect of tax credits on reference baseline EV adoption for both the light-duty and HDPUV analyses. For example, IPI commented that ''[a]lthough NHTSA's baseline modeling includes many commendable elements . . . NHTSA appears to underestimate the baseline share of BEVs resulting from the IRA during the Proposed Rule's compliance period. This, in turn, likely produces an underestimate of baseline average fuel economy and a corresponding overestimate of compliance cost.'' [884] On the other hand, the Corn Growers Associations commented that NHTSA overestimated the CVC, and did not support its assumptions surrounding its credit estimates.[885] In regards to the HDPUV analysis, ACEEE commented that ''[b]y excluding the Commercial Credit from its baseline analysis, NHTSA risks underestimating the additional positive impact that the IRA is projected to have on market penetration of BEVs in its no-action scenarios for passenger cars and HDPUVs.'' [886] Rivian similarly commented that they strongly supported NHTSA's stated intention to consult with EPA to implement the Commercial CVC in the final rule. NHTSA did not receive any comments recommending the agency not include tax credits in the final rule.

NHTSA believes that its approach to modeling available tax credits reasonably represents the ways that tax credits could be applied to vehicles in the reference baseline during the years covered by the standards. NHTSA disagrees that its assumptions were not well supported and notes that the agency included a significant and transparent discussion of the modeling assumptions the agency used in the NPRM and associated technical documents. However, for this final rule, NHTSA has refined important aspects of its tax credit modeling and presents additional supporting documentation about those assumptions in Section III.C.5, above, and in Chapter 2 of the Final TSD. In particular, for the final rule analysis in response to comments and in light of further guidance from the Department of Treasury, NHTSA modeled the § 45W tax credit jointly with § 30D. NHTSA believes that these additional updates ensure the agency's handling of tax credits does not over or underestimate their effect in the reference baseline.

The No-Action Alternative for the passenger car, light truck, and HDPUV fleets also includes NHTSA's

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stated that OMB guidance cannot trump a statute. NHTSA disagrees that the agency is trying to ''trump'' 49 U.S.C. 32902(h) by observing guidance in OMB Circular A–4; but, regardless in the case of the HDPUV program where there is no similar command to 49 U.S.C. 32902(h), NHTSA considers OMB guidance on the analytical baseline to be instructive.

[878] North American Council for Freight Efficiency, Run on Less—Electric, available at *https://nacfe.org/research/run-on-less-electric/#vans-step-vans*.

[879] *Id.*

[880] 26 U.S.C. 45X. If a manufacturer produces a battery module without battery cells, they are eligible to claim up to $45 per kWh for the battery module. The provision includes other provisions related to vehicles such as a credit equal to 10 percent of the manufacturing cost of electrode active materials, and another 10 percent for the manufacturing cost of critical minerals. We are not modeling these credits directly because of how we estimate battery costs and to avoid the potential to double count the tax credits if they are included into other analyses that feed into our inputs.

[881] 26 U.S.C. 30D.

[882] There are vehicle price and consumer income limitations on the CVC as well, see Congressional Research Service. Tax Provisions in the Inflation Reduction Act of 2022 (H.R. 5376). Aug. 10, 2022.

[883] 26 U.S.C. 45W.

[884] The Institute for Policy Integrity at New York University School of Law, NHTSA–2023–0022–60485, at 21–22.

[885] Corn Growers Associations, Docket No. NHTSA–2023–0022–62242, at 13–15.

[886] ACEEE, Docket No. NHTSA–2023–0022–60684, at 9.

assumption, for purposes of compliance simulations, that manufacturers will add fuel economy- or fuel efficiency-improving technology voluntarily, if the value of future undiscounted fuel savings fully offsets the cost of the technology within 30 months. This assumption is often called the ''30-month payback'' assumption, and NHTSA has used it for many years and in many CAFE rulemakings.[887] It is used to represent consumer demand for fuel economy. It can be a source of apparent ''over-compliance'' in the No-Action Alternative, especially when technology is estimated to be extremely cost-effective, as occurs later in the analysis time frame when learning has significant effects on some technology costs.

NHTSA has determined that manufacturers do at times improve fuel economy even in the absence of new standards, for several reasons. First, overcompliance is not uncommon in the historical data, both in the absence of new standards, and with new standards—NHTSA's analysis in the 2022 TSD included CAFE compliance data showing that from 2004–2017, while not *all* manufacturers consistently over-complied, a number did. Of the manufacturers who did over-comply, some did so by 20 percent or more, in some fleets, over multiple model years.[888] Ordinary market forces can produce significant increases in fuel economy, either because of consumer demand or because of technological advances.

Second, manufacturers have consistently told NHTSA that they do make fuel economy improvements where the cost can be fully recovered in the first 2–3 years of ownership. The 2015 NAS report discussed this assumption explicitly, stating: ''There is also empirical evidence supporting loss aversion as a possible cause of the energy paradox. Greene (2011) showed that if consumers accurately perceived the upfront cost of fuel economy improvements and the uncertainty of fuel economy estimates, the future price of fuel, and other factors affecting the present value of fuel savings, the loss-averse consumers among them would appear to act as if they had very high discount rates or required payback periods of about 3 years.'' [889] Furthermore, the 2020 NAS HD report states: ''The committee has heard from manufacturers and purchasers that they look for 1.5- to 2-year paybacks or, in other cases, for a payback period that is half the expected ownership period of the first owner of the vehicle.'' [890] Naturally, there are heterogenous preferences for vehicle attributes in the marketplace: at the same time that we are observing record sales of electrified vehicles, we are also seeing sustained demand for pickup trucks with higher payloads and towing capacity and hence lower fuel economy. This analysis, like all the CAFE analyses preceding it, uses an average value to represent these preferences for the CAFE fleet and the HDPUV fleet. The analysis balances the risks of estimating too low of a payback period, which would preclude most technologies from consideration regardless of potential cost reductions due to learning, against the risk of allowing too high of a payback period, which would allow an unrealistic cost increase from technology addition in the reference baseline fleet.

Third, as in previous CAFE analyses, our fuel price projections assume sustained increases in real fuel prices over the course of the rule (and beyond). As readers are certainly aware, fuel prices have changed over time—sometimes quickly, sometimes slowly, generally upward. See further details of this in TSD Chapter 3.2.

In the 1990s, when fuel prices were historically low, manufacturers did not tend to improve their fuel economy, likely in part because there simply was very little consumer demand for improved fuel economy and CAFE standards remained flat due to appropriations riders from Congress preventing their increase. In subsequent decades, when fuel prices were higher, many of them have exceeded their standards in multiple fleets, and for multiple years. Our current fuel price projections look more like the last two decades, where prices have been more volatile, but also closer to $3/gallon on average. In recent years, when fuel prices have generally declined on average and CAFE standards have continued to increase, fewer manufacturers have exceeded their standards. However, our compliance data show that at least some manufacturers do improve their fuel economy if fuel prices are high enough, even if they are not able to respond perfectly to fluctuations precisely when they happen. This highlights the importance of fuel price assumptions both in the analysis and in the real world on the future of fuel economy improvements.

Stakeholders commented that the 30-month/2.5-year payback assumption should be shorter (or nonexistent) or significantly longer and specifically mentioned the effects of that assumption and alternative assumptions on the reference baseline. Consumer Reports reiterated their opposition to NHTSA's inclusion of the 2.5-year payback assumption, citing previous comments they had submitted to past CAFE rules and discussing additional historical data and arguments.[891] The Joint NGOs also re-submitted comments to prior rules opposing the 30-month payback assumptions.[892]

On the other hand, CEA commented in opposition to the use of a 30-month payback period and stated that it should be significantly longer, and pointed to NHTSA's 60-month sensitivity case as an example of how that assumption was important enough to be included in the main analysis.[893] Valero also commented in opposition to the 30-month payback assumption specifically in the HDPUV analysis, calling it ''unsupported'' and identified a situation where ''between model year 2029 and 2030, the CAFE Model projects that 168 models of Conventional, MHEV, or SHEV HDPUVs will be converted to BEVs in the No Action scenario—only 40 of those powertrain conversions have a modeled ''Payback'' of less than 30 months, and none have a ''Payback TCO'' of less than 30 months.'' [894] CEA similarly commented in opposition to the use of a 30-month payback period in the HDPUV analysis.[895]

In preparation for this final rule, NHTSA updated its review of research supporting the 30-month payback assumption and continued to use that

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[887] Even though NHTSA uses the 30-month payback assumption to assess how much technology manufacturers would add voluntarily in the absence of new standards, the benefit-cost analysis accounts for the full lifetime fuel savings that would accrue to vehicles affected by the standards.

[888] *See* 2022 TSD, at 68.

[889] NRC. 2015. Cost, Effectiveness, and Deployment of Fuel Economy Technologies for Light-Duty Vehicles. *The National Academies Press:* Washington, DC. Page 31. Available at: *https://doi.org/10.17226/21744.* (Accessed: Feb. 27, 2024) and available for review in hard copy at DOT headquarters). (hereinafter ''2015 NAS report'').

[890] National Academies of Sciences, Engineering, and Medicine. 2020. Reducing Fuel Consumption and Greenhouse Gas Emissions of Medium- and Heavy-Duty Vehicles, Phase Two: Final Report. *The National Academies Press:* Washington, DC, at 296. Available at: *https://doi.org/10.17226/25542.* (Accessed: May 31, 2023).

[891] Consumer Reports, Docket No. NHTSA–2023–0022–61098, at 20–22.

[892] Joint NGOs, Docket No. NHTSA–2023–0022–61944, Attachment 3.

[893] CEA, Docket No. NHTSA–2023–0022–61918, at 18.

[894] Valero, Docket No. NHTSA–2023–0022–58547, Attachment A, at 10.

[895] CEA, Docket No. NHTSA–2023–0022–61918, at 18.

value for this final rule. Additional details on this research survey are discussed in Section III.E, above, and in detail in FRIA Chapter 2.1.4. NHTSA also performed a range of sensitivity cases using different payback assumptions, and those cases are discussed in detail in FRIA Chapter 9. While NHTSA modeled those cases to determine the effect of different payback assumptions on the levels of standards, NHTSA still believes that 30 months is the most appropriate value to use for the central analysis. Regarding Valero's comment about cost-effective technology application in the HDPUV analysis, NHTSA believes that Valero is missing the effect of tax credits in the effective cost calculation. When the CAFE Model determines if a technology is cost effective, it assesses the total cost of applying that technology and subtracts any available tax credits, fuel savings, and reduction in fines (if applicable for the analysis). The columns in the output file that Valero references in their comments is what the CAFE Model computes internally for only fuel savings for each vehicle and does not include tax credits or fines (if applicable). Additional details on the effective cost calculation are included in Section III.C.6 above and in the FRM CAFE Model Documentation.

NHTSA also received several general comments that reiterated the need for the agency to accurately consider EVs in the reference baseline, unrelated to state ZEV programs, tax credits, or consumer willingness to pay for increased fuel economy. Rivian commented that ''ignoring [EVs] in determining how automakers can and should improve fuel economy in their fleets is nonsensical.'' [896] As discussed above, the Joint NGOs commented that ''consistent with EPCA's language, history, and legislative intent, NHTSA models an accurate, real-world 'no action' baseline as a starting point for the rulemaking, a task that requires a rational accounting of the real-world BEVs and PHEVs projected to exist in the absence of the CAFE standards NHTSA is considering setting.'' [897] However, the Joint NGOs stated that ''in an abundance of caution'' in light of the ongoing litigation in *NRDC* v. *NHTSA*, No. 221080 (D.C. Cir.), NHTSA should ''model and evaluate the effect of alternative ways in which it could account for the real-world existence of BEVs/PHEVs in regulatory no-action alternatives,'' like changing its assumptions surrounding compliance with state ZEV programs.

NHTSA also received several requests for the agency to account for manufacturer EV announcements in the reference baseline, or general comments that because manufacturer EV announcements were not included in the reference baseline, NHTSA's reference baseline underrepresented future EV penetration rates. Consumer Reports commented that ''[i]n order to finalize a rule that achieves its statutory requirements to set maximum feasible standards that continue to reduce fuel consumption from gasoline-powered vehicles, NHTSA must appropriately consider the market share of electric vehicles that will exist in the fleet in the absence of the CAFE rule. Failure to consider the significant and rapidly growing sales of electric vehicles will result in a rule that serves no useful purpose, because the stringency will be too low to affect automakers' decisions to deploy fuel saving technology.'' [898] However, Consumer Reports also stated that they found the percentage of EVs in NHTSA's modeled reference baseline to be ''extremely conservative'' based on projections of future EV market share: ''even some of the most cautious estimates are significantly greater than NHTSA's constrained baseline, indicating that it is an extremely conservative approach'' [899] Similarly, the States and Cities commented that ''[b]ecause NHTSA's modeling does not account for significant zero-emission vehicle sales outside of the States adopting ACCI/II and ACT, its No-Action scenario likely significantly underestimates the zero emission vehicles in the baseline fleet. Because this underestimation may result in less stringent standards than are truly the ''maximum feasible'' standards, 49 U.S.C. 32902(a), NHTSA should consider modeling zero-emission vehicle adoption in States not adopting ACCI/II and ACT.'' [900] Tesla likewise commented that ''NHTSA's baseline suggests BEV technology market penetration rates that are low,'' and that NHTSA ''must ensure it utilize[s public commitments from manufacturers] in its analysis of the industry and recognize shifts towards BEV technology in the marketplace is occurring for reasons outside of the CAFE standards setting process.''

NHTSA agrees that having an accurate reference baseline results in a more accurate analysis. However, in practice, it can be difficult to model manufacturer deployment plans without the structure that a regulatory program provides. NHTSA believes that the agency's modeling methodology, which incorporates state ZEV requirements that are legally binding and manufacturer commitments to deploy electric vehicles that would be consistent with the targets of California's ACC II program, regardless of whether it receives a waiver of Clean Air Act preemption, is the most reasonable approach available to the agency at present. Per the nature of NHTSA's standard-setting modeling, the agency recognizes that the reference baseline will necessarily reflect fewer EVs than will likely exist in the future fleet. However, the approach used to construct the reference baseline necessarily reflects the data constraints under which NHTSA was operating regarding manufacturer plans outside of voluntary alignment with ACC II. Regarding NRDC's comment, NHTSA did model several alternative ways that manufacturers could comply with the agency's standards, including as assessed against an alternative baseline that does not include state ZEV programs or voluntary deployment consistent with ACC II. The alternative baseline and range of sensitivity cases that NHTSA modeled, and results are discussed in more detail in Chapters 3 and 9 of the FRIA, and the No ZEV alternative baseline is discussed further below.

Lastly, regarding the reference baseline, the Joint NGOs commented that the methodology of holding the reference baseline constant for years prior to the start of the analysis year unrealistically restricted automakers from adopting fuel economy improving technologies they might otherwise adopt in response to increasingly stringent standards.[901] The Joint NGOs stated that this modeling decision had a significant effect on the reference baseline, ''particularly for the standard-setting runs where additional, economically efficient electric vehicle technologies cannot be deployed in the model year 2027–2032 period.'' [902] The Joint NGOs also stated that NHTSA did not explain this methodology or decision in any of the agency's rulemaking documents.

By way of additional background on this modeling approach: any fleet improvements obtained when evaluating the No-Action Alternative during model years 2022–2026 for the

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[896] Rivian, Docket No. NHTSA–2023–0022–59765, at 3.

[897] Joint NGOs, Docket No. NHTSA–2023–0022–61944, Attachment 2, at 56–57.

[898] Consumer Reports, Docket No. NHTSA–2023–0022–61098, at 13–15.

[899] Consumer Reports, Docket No. NHTSA–2023–0022–61098, at 15.

[900] States and Cities, Docket No. NHTSA–2023–0022–61904, Attachment 2, at 41.

[901] Joint NGOs, Docket No. NHTSA–2023–0022–61944, Attachment 2, at 8.

[902] *Id.*

passenger car and light truck fleets, and during model years 2022–2029 for the HDPUV fleet will be carried over into the Action Alternatives for the same range of model years. Additionally, during those ''reference baseline'' set of years, any further fleet upgrades will not be performed under the Action Alternatives. For the Action Alternatives, technology evaluation and fleet improvements will then begin starting with the first standard-setting year, which is model year 2027 for passenger cars and light trucks, and model year 2030 for HDPUV. Doing so prevents the reference baseline years from being affected by standards defined under the Action Alternatives and ensures that the reference baseline years remain constant irrespective of the alternative being evaluated.

NHTSA believes that this approach captures the impact of new regulations more accurately, as compared to the previously established standards defined under the No-Action Alternative. More specifically, this better allows the agency to capture the costs and benefits of the range of standards being considered. If NHTSA allowed manufacturers to apply technology in advance of increasing standards in later model years, the costs and benefits of those improvements would be attributable to the reference baseline and not NHTSA's action. Moreover, this approach provides an additional level of certainty that the model is not selecting BEV technology in the reference baseline before the operative standards begin to take effect. Put another way, this requirement was intended to ensure that the model does not simulate manufacturers creating new BEVs prior to the standard-setting years in anticipation of the need to comply with the CAFE standards during those standard-setting years. It is exactly the situation that the Joint NGOs describe—that the model might apply BEV technology in the reference baseline but in response to the standards—that NHTSA seeks to avoid in order to fully comply with 49 U.S.C. 32902(h). In sum, not only does this approach allow NHTSA to better capture the costs and benefits of different levels of standards under consideration, but it ensures the modeling comports with all relevant statutory constraints.

2. Alternative Baseline/No-Action Alternative

In addition to the reference baseline for the passenger car and light truck fleet analysis, NHTSA considered an alternative baseline analysis. This alternative baseline analysis for the passenger car and light truck fleets was performed to provide a greater level of insight into the possibilities of a changing baseline landscape. The alternative baseline analysis is not meant to be a replacement for the reference analysis, but a secondary review of the NHTSA analysis with all of the assumptions from the reference baseline held (see Section IV.B.1 above), except for the assumption of compliance with CARB ZEV programs, and the voluntary deployment of electric vehicles consistent with ACC II. The alternative baseline does not assume manufacturers will comply with any of the California light duty ZEV programs or voluntarily deploy electric vehicles consistent with ACC II during any of the model years simulated in the analysis. Results for this alternative baseline are shown in Chapter 8.2.7 of the FRIA and discussed in more detail in Section VI.

3. Action Alternatives for Model Years 2027–2032 Passenger Cars and Light Trucks

In addition to the No-Action Alternatives, NHTSA has considered five ''action'' alternatives for passenger cars and light trucks, each of which is more stringent than the No-Action Alternative during the rulemaking time frame. These action alternatives are specified below and demonstrate different possible approaches to balancing the statutory factors applicable for passenger cars and light trucks. Section VI discusses in more detail how the different alternatives reflect different possible balancing approaches.

a. Alternative PC1LT3

Alternative PC1LT3 would increase CAFE stringency by 1 percent per year, year over year, for model years 2027–2032 passenger cars, and by 3 percent per year, year over year, for model years 2027–2032 light trucks.

Table IV-10: Passenger Car CAFE Target Function Coefficients for Alternative PC1LT3[903]

	2027	2028	2029	2030	2031	2032 (augural)
a (mpg)	67.63	68.31	69.00	69.70	70.40	71.11
b (mpg)	50.60	51.11	51.63	52.15	52.68	53.21
c (gpm per s.f)	0.00033176	0.00032845	0.00032516	0.00032191	0.00031869	0.00031550
d (gpm)	0.00118417	0.00117232	0.00116060	0.00114900	0.00113751	0.00112613

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[903] The PC, LT, and HDPUV target curve function coefficients are defined in Equation IV–1, Equation IV–2, and Equation IV–3, respectively. See Final TSD Chapter 1.2.1 for a complete discussion about the footprint and work factor curve functions and how they are calculated.

Table IV-11: Light Truck CAFE Target Function Coefficients for Alternative PC1LT3[904]

	2027	2028	2029	2030	2031	2032 (augural)
a (mpg)	55.39	57.10	58.87	60.69	62.56	64.50
b (mpg)	33.30	34.33	35.39	36.48	37.61	38.78
c (gpm per s.f)	0.00036296	0.00035207	0.00034151	0.00033126	0.00032132	0.00031168
d (gpm)	0.00317343	0.00307823	0.00298588	0.00289630	0.00280941	0.00272513

These equations are represented graphically below:

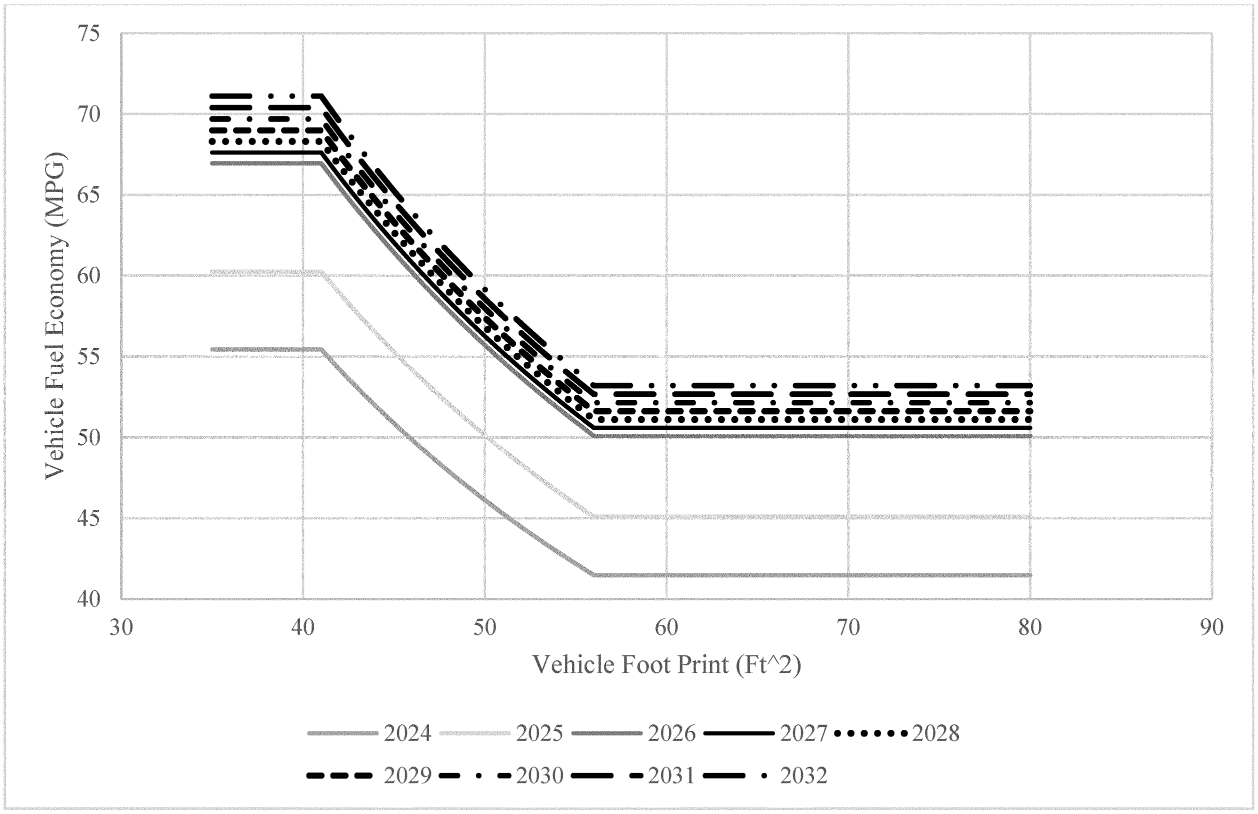

Figure IV-4: Alternative PC1LT3, Passenger Car Fuel Economy, Target Curves

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[904] The PC, LT, and HDPUV target curve function coefficients are defined in Equation IV–1, Equation IV–2, and Equation IV–3, respectively. See Final TSD Chapter 1.2.1 for a complete discussion about the footprint and work factor curve functions and how they are calculated.

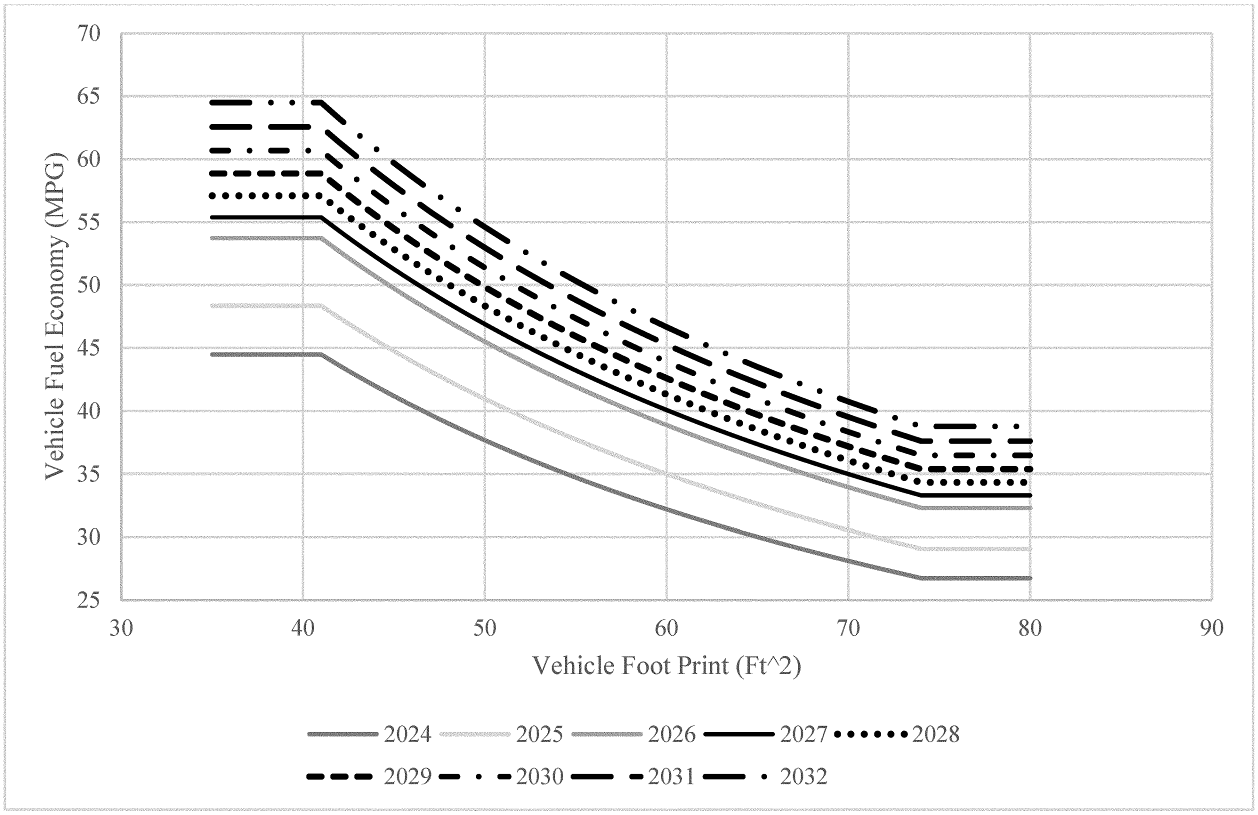

Figure IV-5: Alternative PC1LT3, Light Truck Fuel Economy, Target Curves

Under this alternative, the MDPCS is as follows:

Table IV-12: Alternative PC1LT3 – Minimum Domestic Passenger Car Standard (MDPCS) (MPG)

2027	2028	2029	2030	2031	2032 (augural)
54.6	55.2	55.7	56.3	56.9	57.4

b. Alternative PC2LT002—Final Standards

Alternative PC2LT002 would increase CAFE stringency by 2 percent per year, year over year for model years 2027–2032 for passenger cars, and by 0 percent per year, year over year for model years 2027–2028 light trucks and then 2 percent per year, year over year for model years 2029–2032 for light trucks.

Table IV-13: Passenger Car CAFE Target Function Coefficients for Alternative PC2LT002

	2027	2028	2029	2030	2031	2032 (augural)
a (mpg)	68.32	69.71	71.14	72.59	74.07	75.58
b (mpg)	51.12	52.16	53.22	54.31	55.42	56.55
c (gpm per s.f)	0.00032841	0.00032184	0.00031541	0.00030910	0.00030292	0.00029686
d (gpm)	0.00117220	0.00114876	0.00112579	0.00110327	0.00108120	0.00105958

Table IV-14: Light Truck CAFE Target Function Coefficients for Alternative PC2LT002

	2027	2028	2029	2030	2031	2032 (augural)
a (mpg)	53.73	53.73	54.82	55.94	57.08	58.25
b (mpg)	32.30	32.30	32.96	33.63	34.32	35.02
c (gpm per s.f)	0.00037418	0.00037418	0.00036670	0.00035936	0.00035218	0.00034513
d (gpm)	0.00327158	0.00327158	0.00320615	0.00314202	0.00307918	0.00301760

Table IV-15: Alternative PC2LT002 – Minimum Domestic Passenger Car Standard (MPG)

2027	2028	2029	2030	2031	2032 (augural)
55.2	56.3	57.5	58.6	59.8	61.1

These equations are represented graphically below:

These equations are represented graphically below:

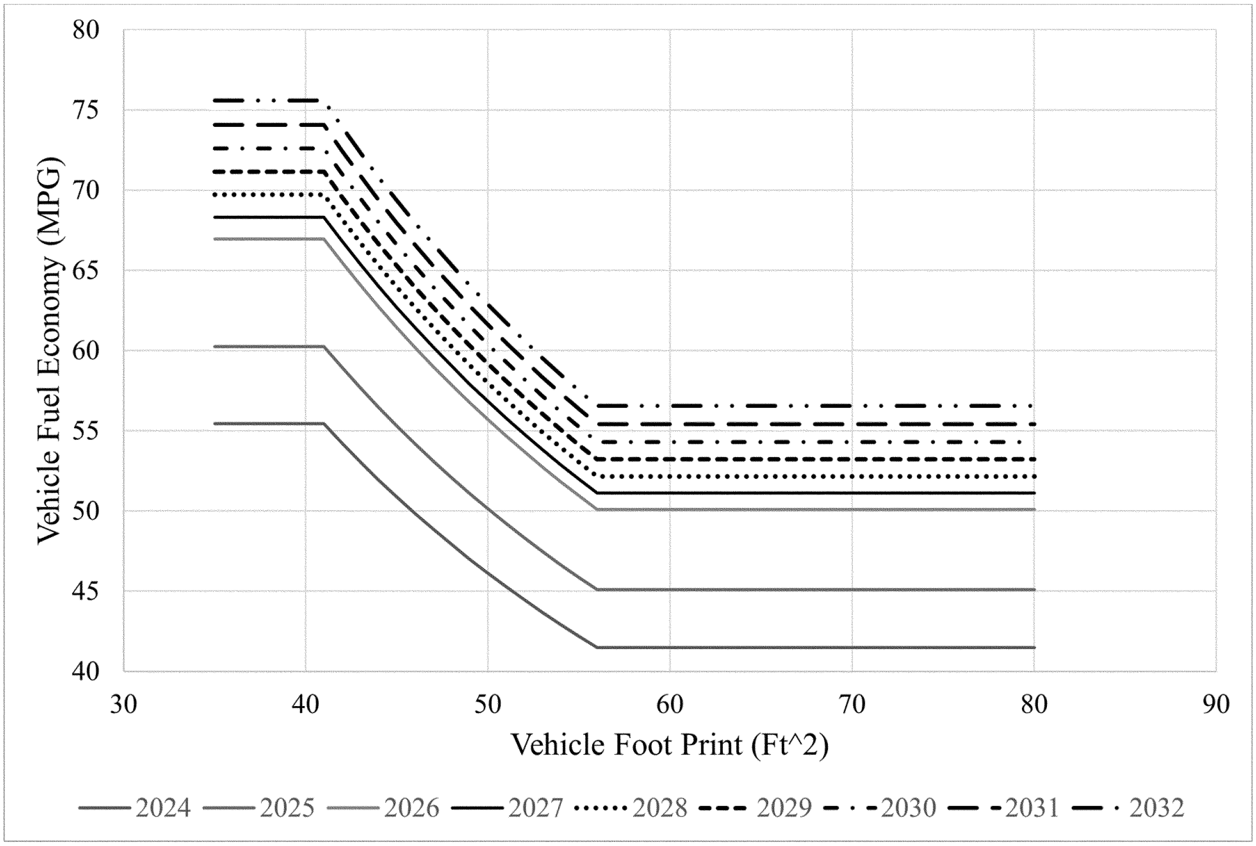

Figure IV-6: Alternative PC2LT002, Passenger Car Fuel Economy, Target Curves

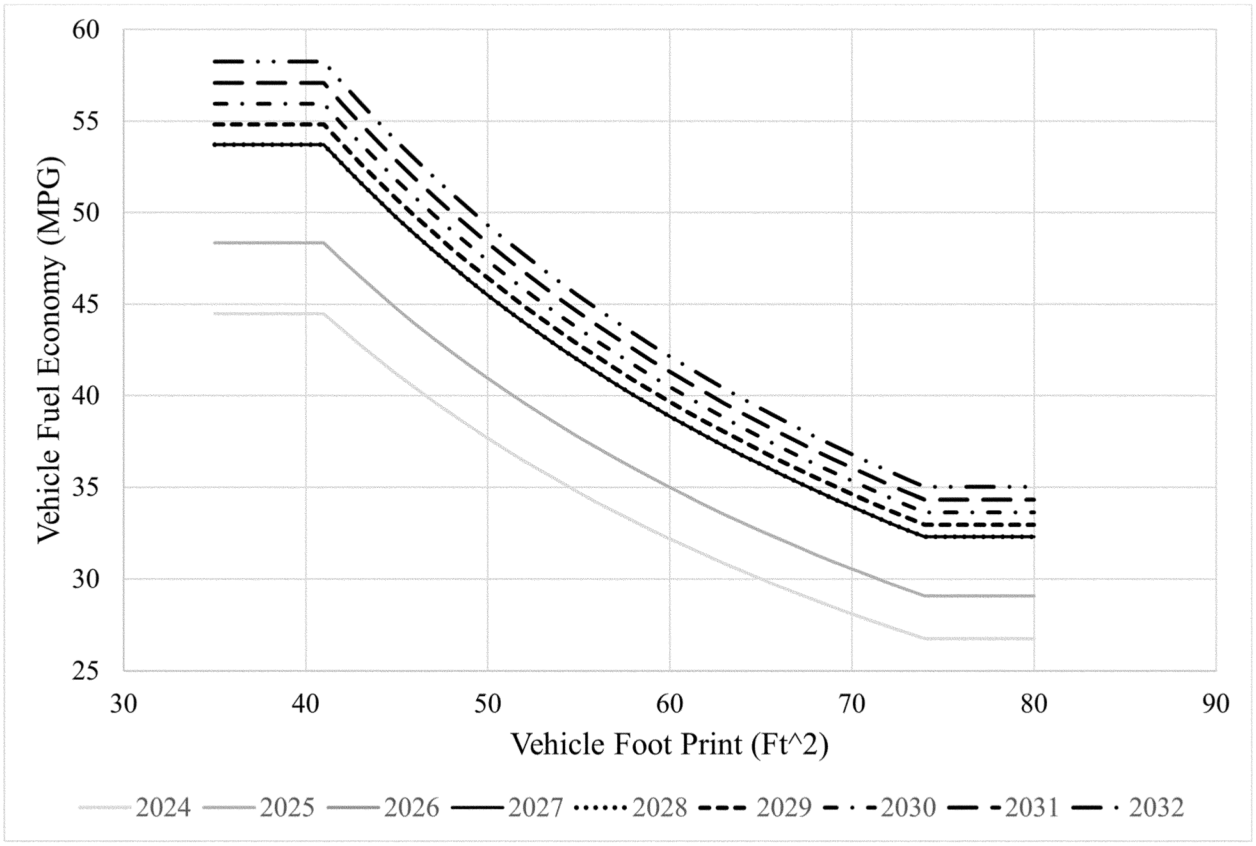

Figure IV-7: Alternative PC2LT002, Light Truck Fuel Economy, Target Curves

c. Alternative PC2LT4

Alternative PC2LT4 would increase CAFE stringency by 2 percent per year, year over year, for model years 2027–2032 for passenger cars, and by 4 percent per year, year over year, for model years 2027–2032 for light trucks.

Table IV-16: Passenger Car CAFE Target Function Coefficients for Alternative PC2LT4[905]

	2027	2028	2029	2030	2031	2032 (augural)
a (mpg)	68.32	69.71	71.14	72.59	74.07	75.58
b (mpg)	51.12	52.16	53.22	54.31	55.42	56.55
c (gpm per s.f)	0.00032841	0.00032184	0.00031541	0.00030910	0.00030292	0.00029686
d (gpm)	0.00117220	0.00114876	0.00112579	0.00110327	0.00108120	0.00105958

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[905] The PC, LT, and HDPUV target curve function coefficients are defined in Equation IV–1, Equation IV–2, and Equation IV–3, respectively. See Final TSD Chapter 1.2.1 for a complete discussion about the footprint and work factor curve functions and how they are calculated.

Table IV-17: Light Truck CAFE Target Function Coefficients for Alternative PC2LT4[906]

	2027	2028	2029	2030	2031	2032 (augural)
a (mpg)	55.96	58.30	60.73	63.26	65.89	68.64
b (mpg)	33.64	35.05	36.51	38.03	39.61	41.26
c (gpm per s.f)	0.00035921	0.00034485	0.00033105	0.00031781	0.00030510	0.00029289
d (gpm)	0.00314071	0.00301509	0.00289448	0.0027870	0.00266755	0.00256085

These equations are represented graphically below:

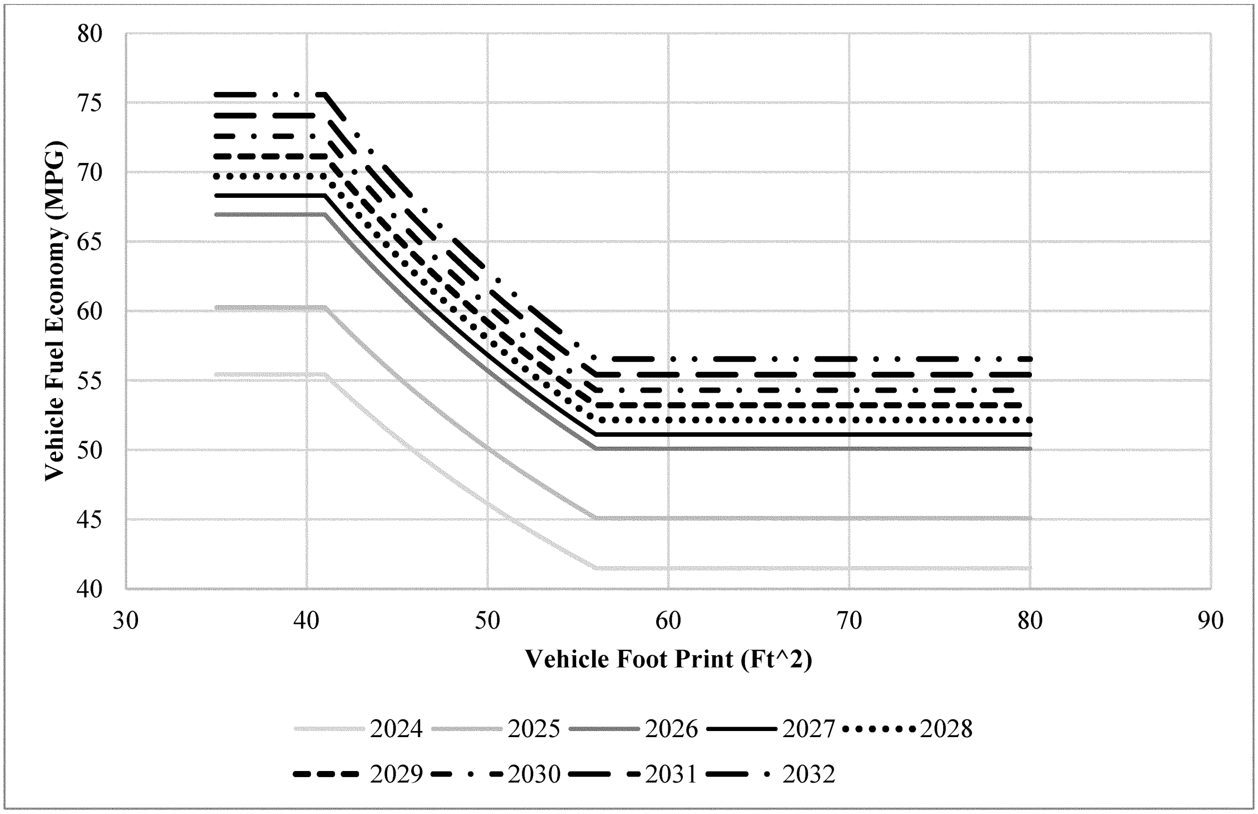

Figure IV-8: Alternative PC2LT4, Passenger Car Fuel Economy, Target Curves

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[906] The PC, LT, and HDPUV target curve function coefficients are defined in Equation IV–1, Equation IV–2, and Equation IV–3, respectively. See Final TSD Chapter 1.2.1 for a complete discussion about the footprint and work factor curve functions and how they are calculated.

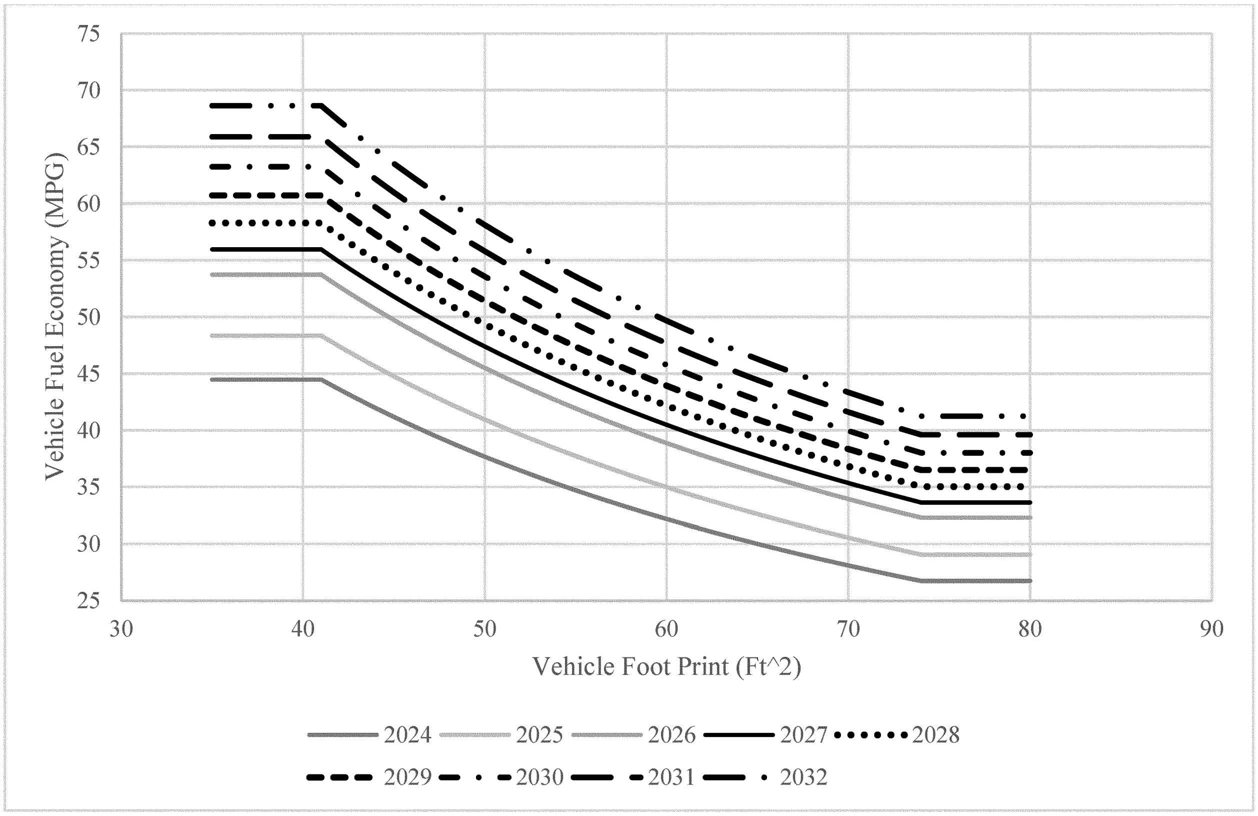

Figure IV-9: Alternative PC2LT4, Light Truck Fuel Economy, Target Curves

Under this alternative, the MDPCS is as follows:

Table IV-18: Alternative PC2LT4 – Minimum Domestic Passenger Car Standard (MPG)

2027	2028	2029	2030	2031	2032 (augural)
55.2	56.3	57.5	58.6	59.8	61.1

d. Alternative PC3LT5

Alternative PC3LT5 would increase CAFE stringency by 3 percent per year, year over year, for model years 2027–2032 for passenger cars, and by 5 percent per year, year over year, for model years 2027–2032 for light trucks.

Table IV-19: Passenger Car CAFE Target Function Coefficients for Alternative PC3LT5[907]

	2027	2028	2029	2030	2031	2032 (augural)
a (mpg)	69.02	71.16	73.36	75.63	77.97	80.38
b (mpg)	51.64	53.24	54.89	56.58	58.33	60.14
c (gpm per s.f)	0.00032506	0.00031531	0.00030585	0.00029668	0.00028777	0.00027914
d (gpm)	0.00116024	0.00112544	0.00109167	0.00105892	0.00102716	0.0099634

Table IV-20: Light Truck CAFE Target Function Coefficients for Alternative PC3LT5[908]

	2027	2028	2029	2030	2031	2032 (augural)
a (mpg)	56.55	59.53	62.66	65.96	69.43	73.09
b (mpg)	34.00	35.79	37.67	39.65	41.74	43.94
c (gpm per s.f)	0.00035547	0.00033770	0.00032081	0.00030477	0.00028954	0.00027506
d (gpm)	0.00310800	0.00295260	0.00280497	0.00266472	0.00253148	0.00240491

These equations are represented graphically below:

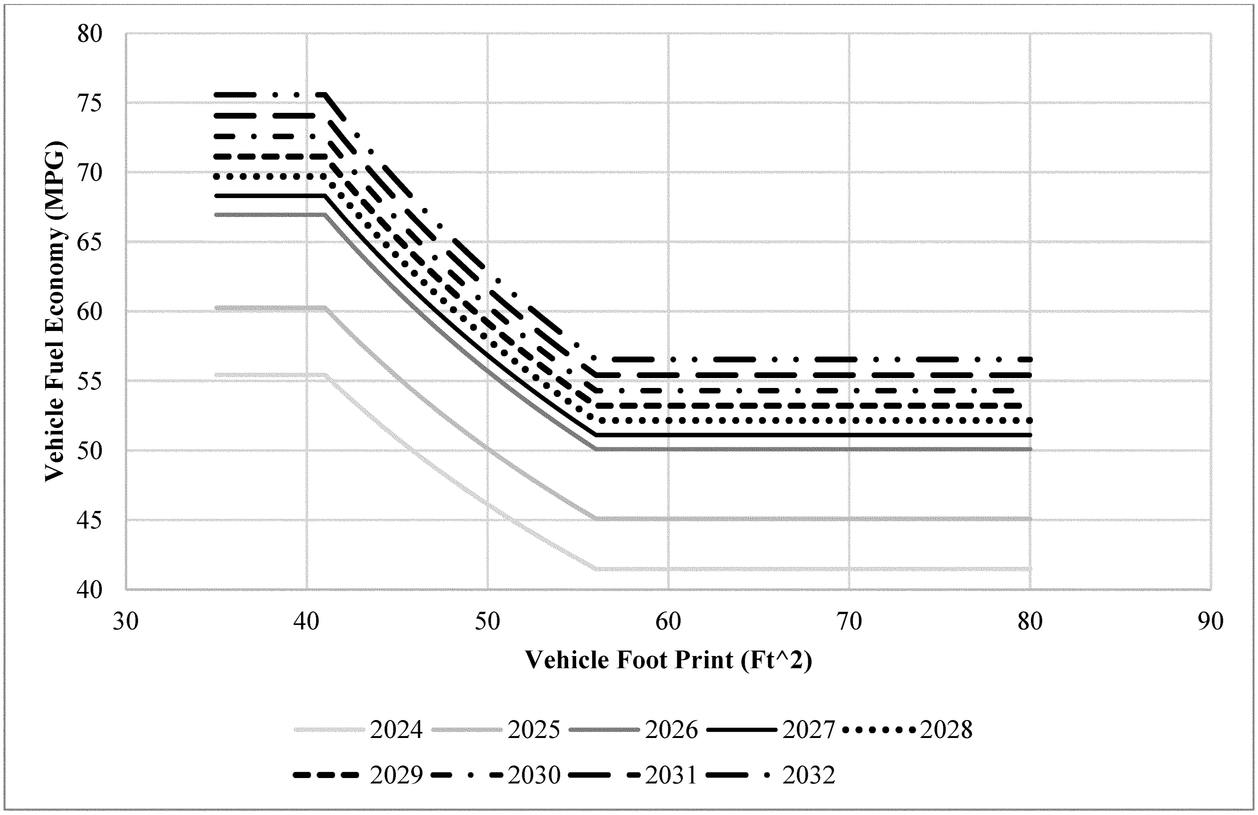

Figure IV-10: Alternative PC3LT5, Passenger Car Fuel Economy, Target Curves

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[907] The PC, LT, and HDPUV target curve function coefficients are defined in Equation IV–1, Equation IV–2, and Equation IV–3, respectively. See Final TSD Chapter 1.2.1 for a complete discussion about the footprint and work factor curve functions and how they are calculated.

[908] The PC, LT, and HDPUV target curve function coefficients are defined in Equation IV–1, Equation IV–2, and Equation IV–3, respectively. See Final TSD Chapter 1.2.1 for a complete discussion about the footprint and work factor curve functions and how they are calculated.

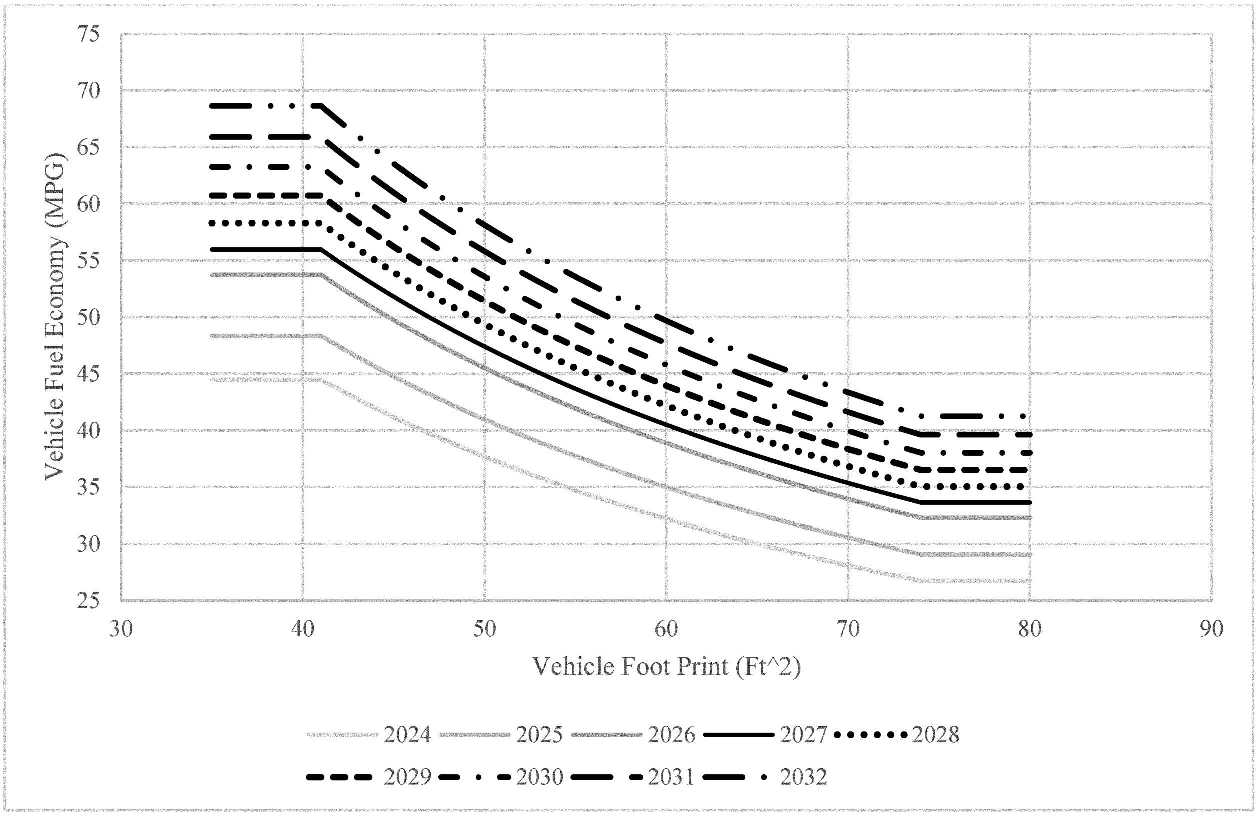

Figure IV-11: Alternative PC3LT5, Light Truck Fuel Economy, Target Curves

Under this alternative, the MDPCS is as follows:

Table IV-21: Alternative PC3LT5 – Minimum Domestic Passenger Car Standard (MPG)

2027	2028	2029	2030	2031	2032 (augural)
55.8	57.5	59.3	61.1	63.0	64.9

e. Alternative PC6LT8

Alternative PC6LT8 would increase CAFE stringency by 6 percent per year, year over year, for model years 2027–2032 for passenger cars, and by 8 percent per year, year over year, for model years 2027–2032 for light trucks.

Table IV-22: Passenger Car CAFE Target Function Coefficients for Alternative PC6LT8[909]

	2027	2028	2029	2030	2031	2032 (augural)
a (mpg)	71.23	75.77	80.61	85.75	91.23	97.05
b (mpg)	53.29	56.69	60.31	64.16	68.26	72.61
c (gpm per s.f)	0.00031501	0.00029611	0.00027834	0.00026164	0.00024594	0.00023119
d (gpm)	0.00112436	0.00105690	0.00099348	0.00093388	0.00087784	0.00082517

Table IV-23: Light Truck CAFE Target Function Coefficients for Alternative PC6LT8[910]

	2027	2028	2029	2030	2031	2032 (augural)
a (mpg)	58.40	63.48	69.00	74.99	81.52	88.60
b (mpg)	35.11	38.16	41.48	45.09	49.01	53.27
c (gpm per s.f)	0.00034425	0.00031671	0.00029137	0.00026806	0.00024662	0.00022689
d (gpm)	0.00300985	0.00276906	0.00254754	0.00234373	0.00215624	0.00198374

These equations are represented graphically below:

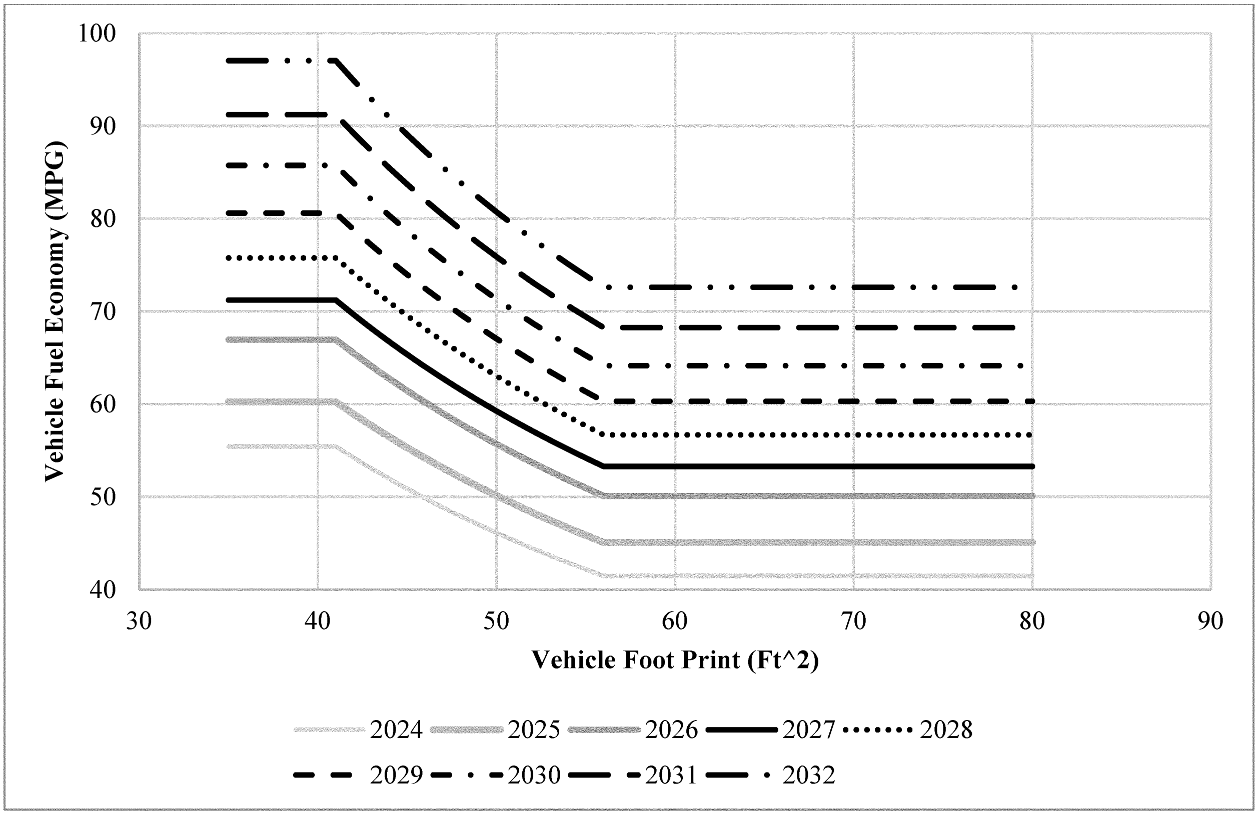

Figure IV-12: Alternative PC6LT8, Passenger Car Fuel Economy, Target Curves

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[909] The PC, LT, and HDPUV target curve function coefficients are defined in Equation IV–1, Equation IV–2, and Equation IV–3, respectively. See Final TSD Chapter 1.2.1 for a complete discussion about the footprint and work factor curve functions and how they are calculated.

[910] The PC, LT, and HDPUV target curve function coefficients are defined in Equation IV–1, Equation IV–2, and Equation IV–3, respectively. See Final TSD Chapter 1.2.1 for a complete discussion about the footprint and work factor curve functions and how they are calculated.

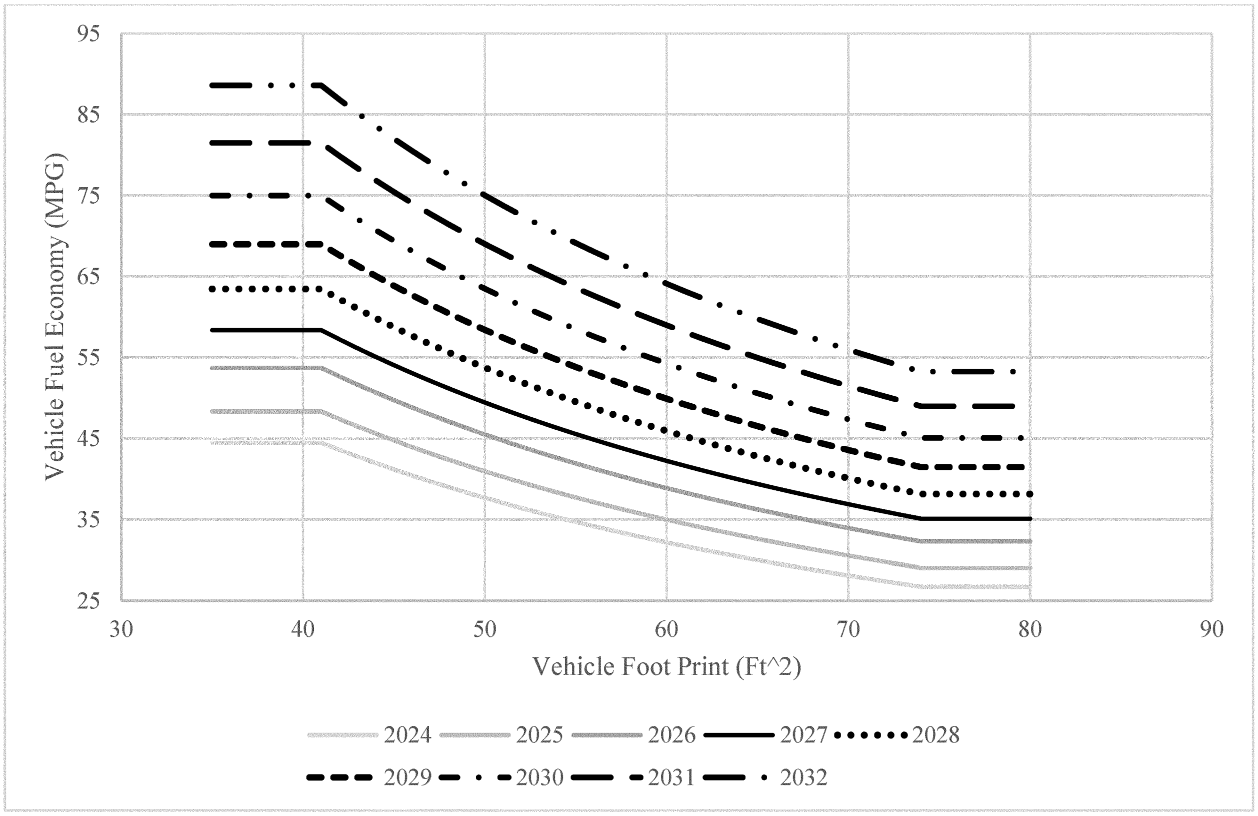

Figure IV-13: Alternative PC6LT8, Light Truck Fuel Economy, Target Curves

Under this alternative, the MDPCS is as follows:

Table IV-24: Alternative PC6LT8 – Minimum Domestic Passenger Car Standard (MPG)

2027	2028	2029	2030	2031	2032 (augural)
57.5	61.2	65.1	69.3	73.7	78.4

f. Other Alternatives Suggested by Commenters for Passenger Car and LT CAFE Standards

Commenters also suggested a variety of other regulatory alternatives for NHTSA to analyze for the final rule.

Rivian commented that NHTSA should increase stringency for light trucks relative to passenger cars by an even greater degree than the proposal, such as "stringency combinations in which standards would increase by 2 percent annually for passenger cars but 5 to 8 percent annually for light trucks."[911] Rivian argued that this was appropriate given "that more stringent light truck targets perform well from a cost-benefit perspective."[912] Rivian also suggested that NHTSA evaluate an alternative in which only light truck standards were increased.[913]

IPI commented that NHTSA should (1) evaluate an alternative which expressly maximizes net benefits (suggesting PC2LT8, specifically), and (2) "assess a broader range of alternatives that decouple increases from light trucks from those for passenger cars and that impose non-linear increases, which could further maximize net benefits."[914]

NHTSA appreciates Rivian's comment; however, we have an obligation to set maximum feasible CAFE standards separately for passenger cars and light trucks (see 49 U.S.C. 32902). We would not be in compliance with our statutory authority if we failed to increase passenger car standards despite concluding that Alternative PC2LT002 is feasible for the industry. Establishing maximum feasible standards involves balancing several factors, which means that some factors, like net benefits, may not reach their maximum level. As previously mentioned, NHTSA is statutorily required to set independent standards for passenger cars and light trucks. As such, NHTSA's preferred alternative contains passenger car and light truck standards that are already "decoupled." Also, the stringency for the light truck fleet is non-linear where it increases by 0 percent per year, year over year for MYs 2027–2028 light trucks and then 2 percent per year, year over year for model years 2029–2031.

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[911] Rivian, Docket No. NHTSA–2023–0022–28017, at 1.

[912] *Id.*

[913] *Id.*

[914] IPI, Docket No. NHTSA–2023–0022–60485, at 1, 6–9.

4. Action Alternatives for Model Years 2030–2035 Heavy-Duty Pickups and Vans

In addition to the No-Action Alternative, NHTSA has considered four action alternatives for HDPUVs. Each of the Action Alternatives, described below, would establish increases in stringency over the No-Action Alternative from model year 2030 through model year 2035.[915] In the NPRM, NHTSA also sought comment on a scenario in which the Action Alternatives would extend only through model year 2032. Ford supported NHTSA ending its HDPUV standards in model year 2032 as more harmonized with EPA's proposed standards, and as aligning ''better . . . with the Inflation Reduction Act's ZEV credits, scheduled to end by 2032.'' [916] Ford suggested re-evaluating the standards for model years 2033–2035 at a later time.[917] Wisconsin DNR, in contrast, stated that ''given the different statutory authorities under which EPA and NHTSA promulgate vehicle standards, it is appropriate for NHTSA to set standards for the model year ranges it has proposed, rather than extending these standards only through 2032 (which would align with the final model year of EPA's proposed multipollutant standards).'' [918]

We believe that setting HDPUV standards through model year 2035 is appropriate based on our review of the baseline fleet and its capability, in addition to the range of technologies that are available for adoption in the rulemaking timeframe. In addition to the advanced credit multiplier that is available for manufacturers until model year 2027, the current standards do not require significant improvements from model year 2027 through model year 2029. Accordingly, our analysis for model years 2030–2035 shows the potential for high technology uptake; this can be seen in detail in RIA Chapter 8. We proposed 10 percent year over year increases and now we are finalizing 8 percent year over year increases. This means that over the six-year period where these standards are in effect, the stringency of our standards almost matches the stringency of the EPA standards in model year 2032. Our regulatory model years are different due to our statutory requirements, however, as our statutory lead time requirements prevented us from harmonizing with EPA directly on the model year 2027–2029 standards.[919] For a more detailed discussion on the lead time for HDPUVs, see Section VI.A.1.b. Section VI also discusses in more detail how the different alternatives reflect different possible balancing approaches for setting HDPUV standards. HDPUV action alternatives are specified below.

a. Alternative HDPUV4

Alternative HDPUV4 would increase HDPUV standard stringency by 4 percent per year for model years 2030–2035 for HDPUVs. NHTSA included this alternative in order to evaluate a possible balancing of statutory factors in which cost-effectiveness outweighed all other factors. The four-wheel drive coefficient is maintained at 500 (coefficient 'a') and the weighting multiplier coefficient is maintained at 0.75 (coefficient 'b').

Table IV-25: HDPUV CI Vehicle Target Function Coefficients for Alternative HDPUV4[920]

	2030	2031	2032	2033	2034	2035
e	0.00032813	0.00031500	0.00030240	0.00029031	0.00027869	0.00026755
f	2.528	2.427	2.330	2.236	2.147	2.061

Table IV-26: HDPUV SI Vehicle Target Function Coefficients for Alternative HDPUV4[921]

	2030	2031	2032	2033	2034	2035
c	0.00039859	0.00038265	0.00036734	0.00035265	0.00033854	0.00032500
d	3.068	2.945	2.828	2.715	2.606	2.502

These equations are represented graphically below:

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[915] *See* 87 FR 29242–29243 (May 5, 2023). NHTSA recognizes that the EIS accompanying this final rule examines only regulatory alternatives for HDPUVs in which standards cover model years 2030–2035.

[916] Ford, Docket No. NHTSA–2023–0022–60837, at 11; *see also* Stellantis, NHTSA–2023–0022–61107, at 3.

[917] *Id.; see also* Alliance, NHTSA–2023–0022–60652, Appendix F, at 62.

[918] Wisconsin DNR, Docket No. NHTSA–2023–0022–21431, at 2.

[919] 49 U.S.C 32902(k)(3).

[920] The PC, LT, and HDPUV target curve function coefficients are defined in Equation IV–1, Equation IV–2, and Equation IV–3, respectively. See Final TSD Chapter 1.2.1 for a complete discussion about the footprint and work factor curve functions and how they are calculated.

[921] The PC, LT, and HDPUV target curve function coefficients are defined in Equation IV–1, Equation IV–2, and Equation IV–3, respectively. See Final TSD Chapter 1.2.1 for a complete discussion about the footprint and work factor curve functions and how they are calculated.

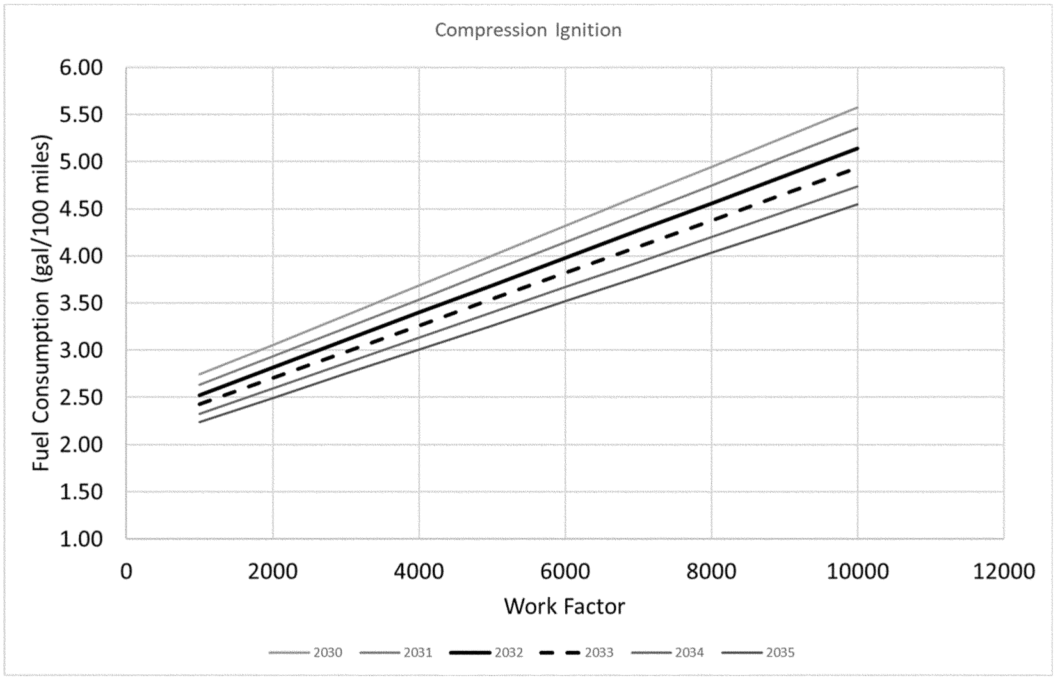

Figure IV-14: Alternative HDPUV4, HDPUV Fuel Efficiency – CI Vehicles, Target Curves

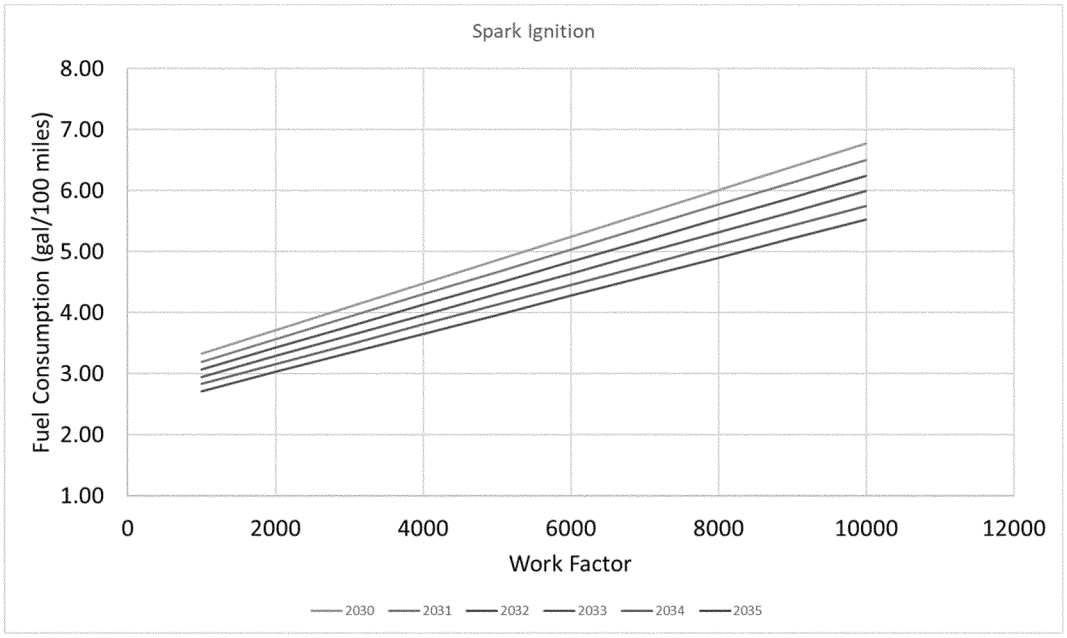

Figure IV-15: Alternative HDPUV4, HDPUV Fuel Efficiency – SI Vehicles, Target Curves

b. Alternative HDPUV108—Final Standards

Alternative HDPUV108 would increase HDPUV standard stringency by 10 percent per year, year over year for model years 2030–2032, and by 8 percent per year, year over year for model years 2033–2035 for HDPUVs. The four-wheel drive coefficient is maintained at 500 (coefficient 'a') and the weighting multiplier coefficient is maintained at 0.75 (coefficient 'b').

Table IV-27: Characteristics of Alternative HDPUV108 – CI Vehicle Coefficients[922]

	2030	2031	2032	2033	2034	2035
e	0.00030762	0.00027686	0.00024917	0.00022924	0.00021090	0.00019403
f	2.370	2.133	1.919	1.766	1.625	1.495

Table IV-28: Characteristics of Alternative HDPUV108 – SI Vehicle Coefficients[923]

	2030	2031	2032	2033	2034	2035
c	0.00037368	0.00033631	0.00030268	0.00027847	0.00025619	0.00023569
d	2.876	2.589	2.330	2.143	1.972	1.814

These equations are represented graphically below:

Figure IV-16: Alternative HDPUV108, HDPUV Fuel Efficiency – CI Vehicles, Target Curves

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[922] The PC, LT, and HDPUV target curve function coefficients are defined in Equation IV–1, Equation IV–2, and Equation IV–3, respectively. See Final TSD Chapter 1.2.1 for a complete discussion about the footprint and work factor curve functions and how they are calculated.

[923] The PC, LT, and HDPUV target curve function coefficients are defined in Equation IV–1, Equation IV–2, and Equation IV–3, respectively. See Final TSD Chapter 1.2.1 for a complete discussion about the footprint and work factor curve functions and how they are calculated.

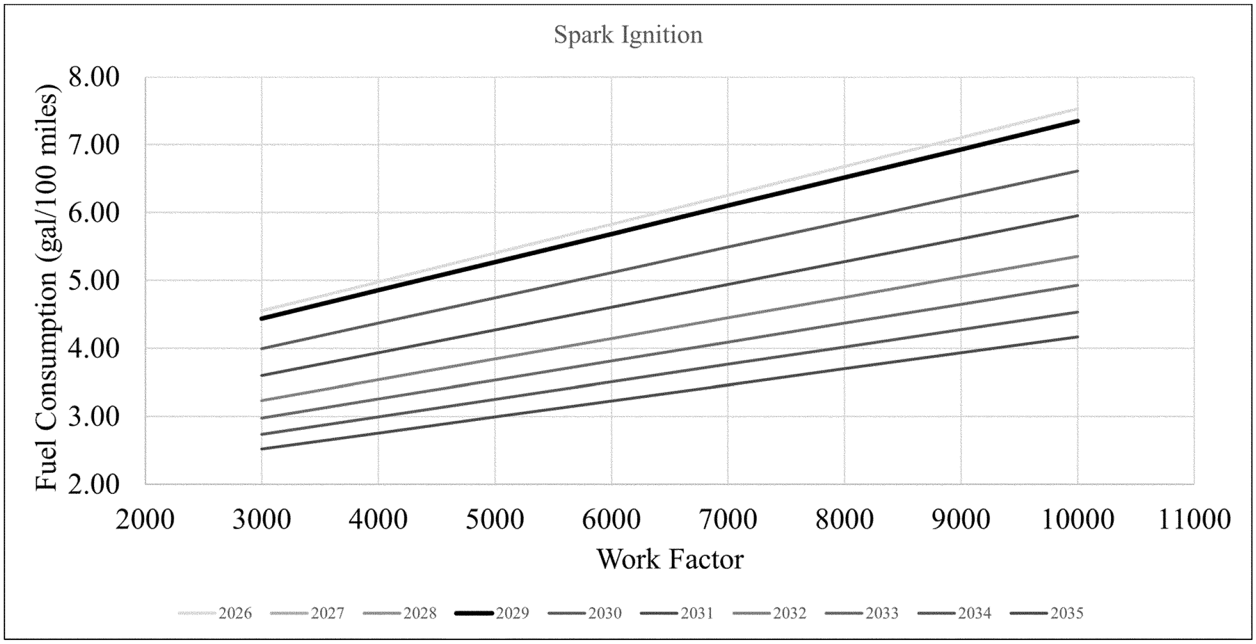

Figure IV-17: Alternative HDPUV108, HDPUV Fuel Efficiency – SI Vehicles, Target Curves

c. Alternative HDPUV10

Alternative HDPUV10 would increase HDPUV standard stringency by 10 percent per year for model years 2030–2035 for HDPUVs. The four-wheel drive coefficient is maintained at 500 (coefficient 'a') and the weighting multiplier coefficient is maintained at 0.75 (coefficient 'b').

Table IV-29: HDPUV CI Vehicle Target Function Coefficients for Alternative HDPUV10[924]

	2030	2031	2032	2033	2034	2035
e	0.00030762	0.00027686	0.00024917	0.00022425	0.00020183	0.00018165
f	2.370	2.133	1.919	1.728	1.555	1.399

Table IV-30: HDPUV SI Vehicle Target Function Coefficients for Alternative HDPUV10[925]

	2030	2031	2032	2033	2034	2035
c	0.00037368	0.00033631	0.00030268	0.00027241	0.00024517	0.00022065
d	2.876	2.589	2.330	2.097	1.887	1.698

These equations are represented graphically below:

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[924] The PC, LT, and HDPUV target curve function coefficients are defined in Equation IV–1, Equation IV–2, and Equation IV–3, respectively. See Final TSD Chapter 1.2.1 for a complete discussion about the footprint and work factor curve functions and how they are calculated.

[925] The PC, LT, and HDPUV target curve function coefficients are defined in Equation IV–1, Equation IV–2, and Equation IV–3, respectively. See Final TSD Chapter 1.2.1 for a complete discussion about the footprint and work factor curve functions and how they are calculated.

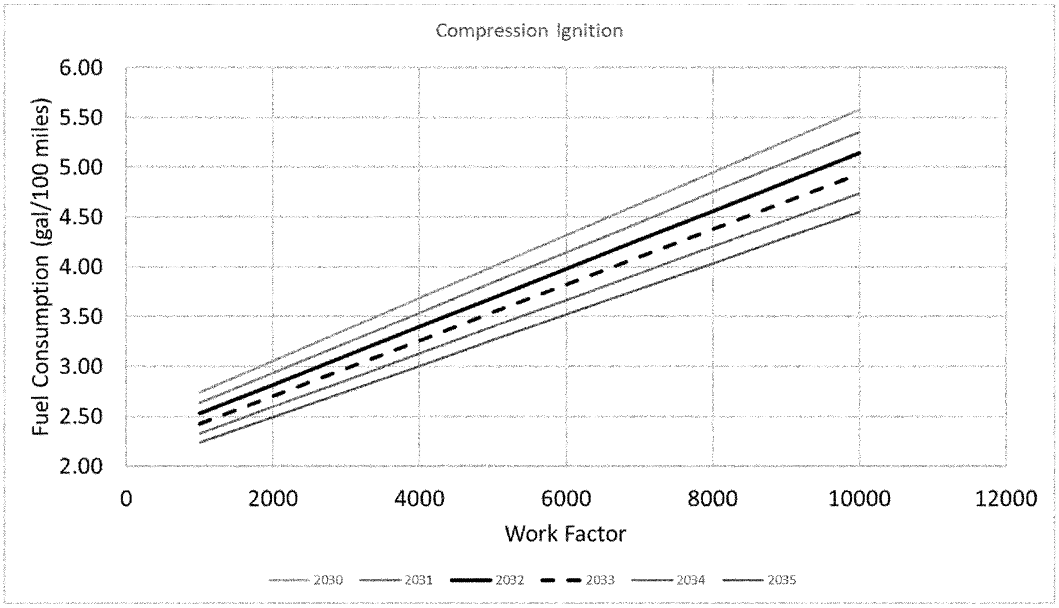

Figure IV-18: Alternative HDPUV10, HDPUV Fuel Efficiency – CI Vehicles, Target Curves

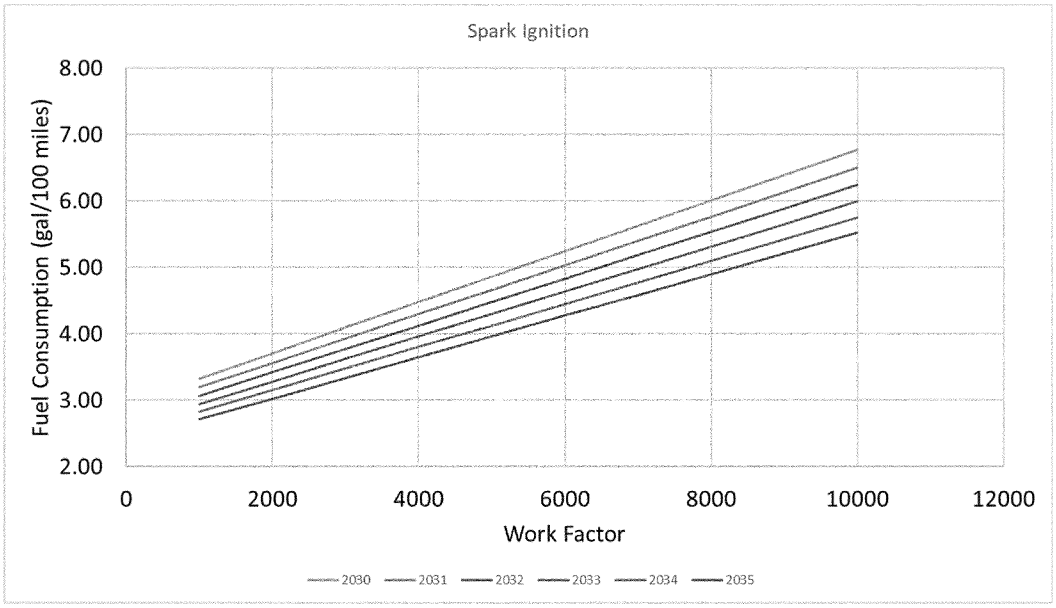

Figure IV-19: Alternative HDPUV10, HDPUV Fuel Efficiency – SI Vehicles, Target Curves

d. Alternative HDPUV14

Alternative HDPUV14 would increase HDPUV standard stringency by 14 percent per year for model years 2030–2035 for HDPUVs. The four-wheel drive coefficient is maintained at 500 (coefficient 'a') and the weighting multiplier coefficient is maintained at 0.75 (coefficient 'b').

Table IV-31: HDPUV CI Vehicle Target Function Coefficients for Alternative HDPUV14[926]

	2030	2031	2032	2033	2034	2035
e	0.00029395	0.00025280	0.00021740	0.00018697	0.00016079	0.00013828
f	2.264	1.947	1.675	1.440	1.239	1.065

Table IV-32: HDPUV SI Vehicle Target Function Coefficients for Alternative HDPUV14[927]

	2030	2031	2032	2033	2034	2035
c	0.00035707	0.00030708	0.00026409	0.00022712	0.00019532	0.00016798
d	2.749	2.364	2.033	1.748	1.503	1.293

These equations are represented graphically below:

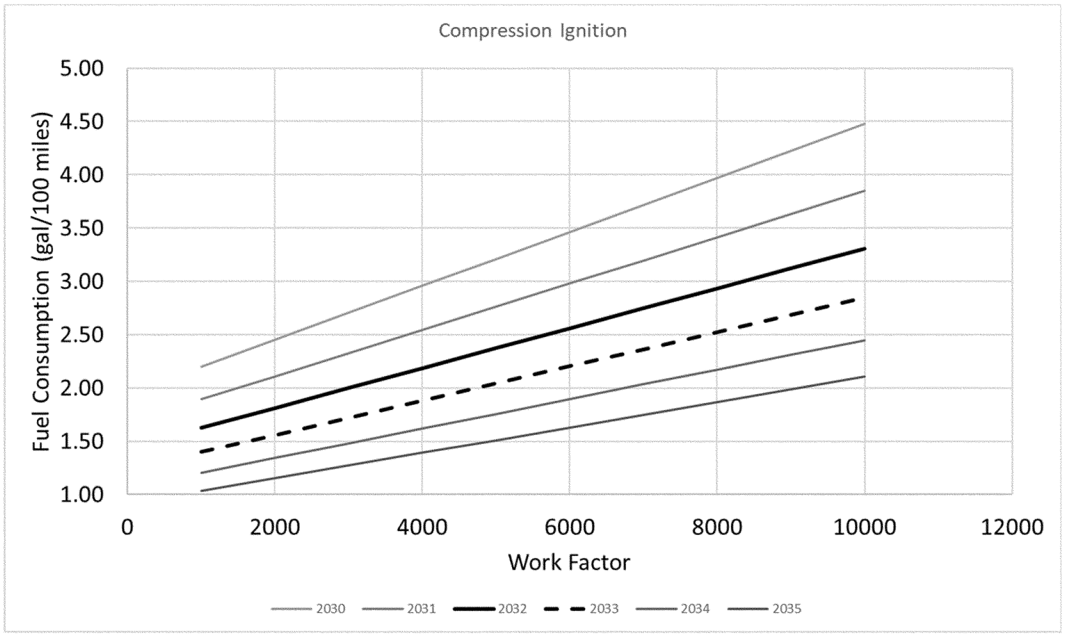

Figure IV-20: Alternative HDPUV14, HDPUV Fuel Efficiency – CI Vehicles, Target Curves

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[926] The PC, LT, and HDPUV target curve function coefficients are defined in Equation IV–1, Equation IV–2, and Equation IV–3, respectively. See Final TSD Chapter 1.2.1 for a complete discussion about the footprint and work factor curve functions and how they are calculated.

[927] The PC, LT, and HDPUV target curve function coefficients are defined in Equation IV–1, Equation IV–2, and Equation IV–3, respectively. See Final TSD Chapter 1.2.1 for a complete discussion about the footprint and work factor curve functions and how they are calculated.

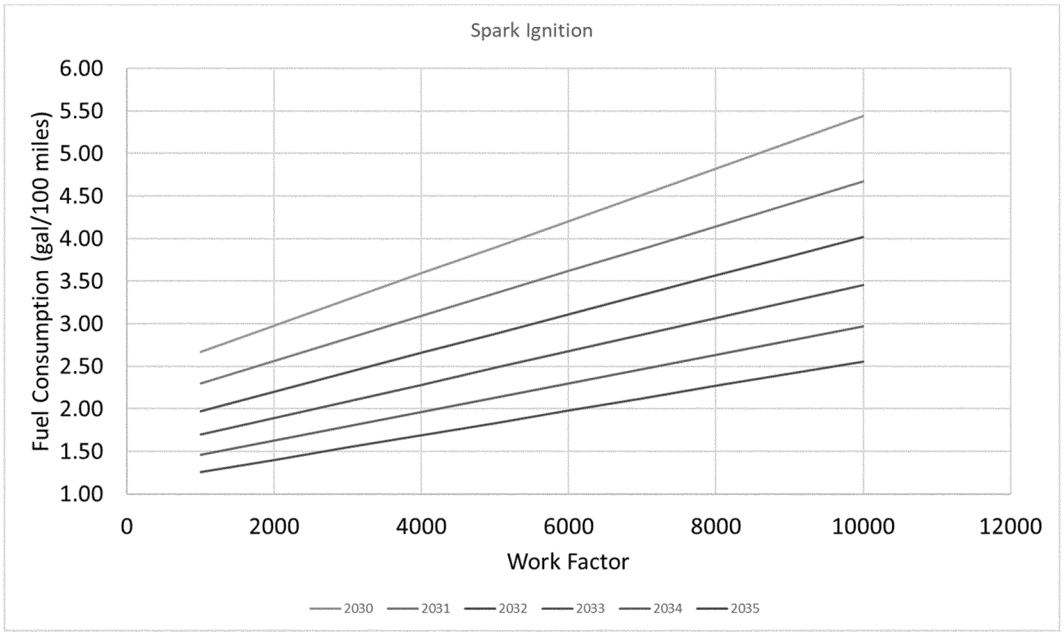

Figure IV-21: Alternative HDPUV14, HDPUV Fuel Efficiency – SI Vehicles, Target Curves

V. Effects of the Regulatory Alternatives

A. Effects on Vehicle Manufacturers

1. Passenger Cars and Light Trucks

Each regulatory alternative considered in this final rule, aside from the No-Action Alternative, would increase the stringency of both passenger car and light truck CAFE standards during model years 2027–2031 (with model year 2032 being an augural standard). To estimate the potential effects of each of these alternatives, NHTSA has, as with all recent rulemakings, assumed that standards would continue unchanged after the last model year to be covered by CAFE targets (in this case model year 2031 for the primary analysis and 2032 for the augural standards). NHTSA recognizes that it is possible that the size and composition of the fleet (*i.e.,* in terms of distribution across the range of vehicle footprints) could change over time, affecting the average fuel economy requirements under both the passenger car and light truck standards, and for the overall fleet. If fleet changes ultimately differ from NHTSA's projections, average requirements would differ from NHTSA's projections.

Following are the estimated required average fuel economy values for the passenger car, light truck, and total fleets for each action alternative that NHTSA considered alongside values for the No-Action Alternative. (As a reminder, all projected effects presented use the reference baseline unless otherwise stated.)

Table V-1: Estimated Required Average Fuel Economy (MPG), by Regulatory Fleet

Model Year	2022	2027	2028	2029	2030	2031
Passenger Car						
No Action	44.1	58.8	58.8	58.8	58.8	58.8
PC2LT002	44.1	60.0	61.2	62.5	63.7	65.1
PC1LT3	44.1	59.4	60.0	60.6	61.2	61.8
PC2LT4	44.1	60.0	61.2	62.5	63.7	65.1
PC3LT5	44.1	60.6	62.5	64.4	66.4	68.5
PC6LT8	44.1	62.5	66.5	70.8	75.3	80.1
Light Truck						
No Action	32.1	42.6	42.6	42.6	42.6	42.6
PC2LT002	32.1	42.6	42.6	43.5	44.3	45.2
PC1LT3	32.1	43.9	45.3	46.7	48.1	49.6
PC2LT4	32.1	44.3	46.2	48.1	50.1	52.2
PC3LT5	32.1	44.8	47.2	49.7	52.3	55.0
PC6LT8	32.1	46.3	50.3	54.7	59.4	64.6

Table V-2: Estimated Required Average Fuel Economy (MPG), Total Light-Duty Fleet

Model Year	2022	2027	2028	2029	2030	2031
No Action	35.8	47.0	46.9	46.9	46.9	46.9
PC2LT002	35.8	47.3	47.4	48.4	49.4	50.4
PC1LT3	35.8	48.2	49.4	50.6	51.9	53.2
PC2LT4	35.8	48.7	50.4	52.2	54.1	56.0
PC3LT5	35.8	49.2	51.5	53.8	56.4	59.0
PC6LT8	35.8	50.8	54.8	59.2	64.0	69.2

Manufacturers do not always comply exactly with each CAFE standard in each model year. To date, some manufacturers have tended to exceed at least one requirement.[928] Many manufacturers in practice make use of EPCA's provisions allowing CAFE compliance credits to be applied when a fleet's CAFE level falls short of the corresponding requirement in a given model year.[929] Some manufacturers have paid civil penalties (*i.e.,* fines) required under EPCA when a fleet falls short of a standard in a given model year and the manufacturer lacks compliance credits sufficient to address the compliance shortfall. As discussed in the accompanying FRIA and TSD, NHTSA simulates manufacturers' responses to each alternative given a wide range of input estimates (*e.g.,* technology cost and efficacy, fuel prices), and, per EPCA requirements, setting aside the potential that any manufacturer would respond to CAFE standards in model years 2027–2031 by applying CAFE compliance credits or considering the fuel economy attributable to alternative fuel sources.[930] Many of these inputs are subject to uncertainty, and, in any event, as in all CAFE rulemakings, NHTSA's analysis simply illustrates one set of ways manufacturers could potentially respond to each regulatory alternative. The tables below show the estimated achieved fuel economy produced by the CAFE Model for each regulatory alternative.

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[928] Overcompliance can be the result of multiple factors including projected "inheritance" of technologies (*e.g.,* changes to engines shared across multiple vehicle model/configurations) applied in earlier model years, future technology cost reductions (*e.g.,* decreased techology costs due to learning), and changes in fuel prices that affect technology cost effectiveness. As in all past rulemakings over the last decade, NHTSA assumes that beyond fuel economy improvements necessitated by CAFE standards, EPA–GHG standards, and ZEV programs, manufacturers may also improve fuel economy via technologies that would pay for themselves within the first 30 months of vehicle operation.

[929] For additional detail on the creation and use of compliance credits, see Chapters 1.1 and 2.2.2.3 of the accompanying TSD.

[930] In the case of battery-electric vehicles, this means BEVs will not be built in response to the standards. For plug-in hybrid vehicles, this means only the gasoline-powered operation (*i.e.,* non-electric fuel economy, or charge sustaining mode operation only) is considered when selecting technology to meet the standards.

Table V-3: Estimated Achieved Average Fuel Economy (MPG), by Regulatory Fleet

Model Year	2022	2027	2028	2029	2030	2031
Passenger Car						
No Action	47.1	69.3	68.6	67.9	67.5	69.8
PC2LT002	47.1	68.6	68.4	68.6	68.6	70.8
PC1LT3	47.1	68.2	67.8	67.6	67.3	69.1
PC2LT4	47.1	68.6	68.5	68.7	68.7	70.8
PC3LT5	47.1	68.8	68.9	69.5	70.1	73.0
PC6LT8	47.1	69.0	70.8	72.5	74.3	78.6
Light Truck						
No Action	32.1	44.1	44.2	44.7	45.0	46.2
PC2LT002	32.1	43.7	44.2	44.9	45.3	46.4
PC1LT3	32.1	44.3	45.1	46.2	46.9	48.1
PC2LT4	32.1	44.5	45.6	46.7	47.8	49.2
PC3LT5	32.1	44.5	45.7	47.0	48.1	49.8
PC6LT8	32.1	44.6	45.9	47.4	48.7	50.3

Table V-4: Estimated Achieved Average Fuel Economy (MPG), Total Light-Duty Fleet

Model Year	2022	2027	2028	2029	2030	2031
No Action	36.5	50.3	50.3	50.5	50.7	52.1
PC2LT002	36.5	49.9	50.2	50.8	51.1	52.5
PC1LT3	36.5	50.3	50.9	51.7	52.3	53.7
PC2LT4	36.5	50.5	51.4	52.4	53.3	54.9
PC3LT5	36.5	50.6	51.6	52.7	53.9	55.9
PC6LT8	36.5	50.7	52.1	53.6	55.2	57.4

While these increases in estimated fuel economy levels are partially attributable to changes in the composition of the fleet as simulated by the CAFE Model (*i.e.,* the relative shares of passenger cars and light trucks), they result almost entirely from the projected application of fuel-saving technology. Manufacturers' actual responses will almost assuredly differ from NHTSA's simulations, and therefore the achieved compliance levels will differ from these tables.

The SHEV share of the light-duty fleet initially (*i.e.,* in model year 2022) is relatively low, but increases to approximately 23 to 27 percent by the beginning of the final rule's regulatory period (MY2027). Across action alternatives, SHEV penetration rates increase as alternatives become more stringent, in both the passenger car and light truck fleets. SHEVs are estimated to make up a larger portion of light truck fleet than passenger car fleet across model years 2027–2031. While their market shares do not increase to the levels of SHEVs, PHEVs make up between 7 to 8 percent of the estimated light truck fleet across the alternatives by the end of the regulatory period. In the passenger car fleet, PHEV penetration stays under 2 percent for all alternatives and all model years. Variation in penetration rates across alternatives generally results from how many vehicles or models require additional technology to become compliant, *e.g.* one technology pathway is the most cost-effective pathway if a manufacturer is just shy of their fuel economy target, but becomes ineffective if there's a larger gap which may necessitate pursuing broader changes in powertrain across the manufacturers' fleet. For example, Honda is projected to redesign several of its models from MHEV to PHEV in 2027. This accounts for the slightly increased PHEV penetration rate in PC2LT002.[931] For more detail on the technology application by regulatory fleet, see FRIA Chapter 8.2.2.1.

Table V-5: Estimated Strong Hybrid Electric Vehicle (SHEV) Penetration Rate, by Regulatory Fleet

Model Year	2022	2027	2028	2029	2030	2031
Passenger Car						
No Action	5.4	8.4	8.5	8.9	8.6	8.2
PC2LT002	5.4	11.3	13.1	17.4	18.6	19.9
PC1LT3	5.4	10.8	11.4	15.3	15.1	14.8
PC2LT4	5.4	12.9	14.7	18.9	19.9	20.5
PC3LT5	5.4	13.0	14.7	21.0	25.0	28.5
PC6LT8	5.4	13.7	24.2	33.6	40.7	47.9
Light Truck						
No Action	7.8	29.5	30.0	32.3	31.8	30.9
PC2LT002	7.8	28.4	31.5	35.2	35.7	32.6
PC1LT3	7.8	32.3	39.2	45.2	48.0	45.4
PC2LT4	7.8	33.4	41.5	47.7	52.6	51.2
PC3LT5	7.8	33.7	42.1	48.8	54.0	53.9
PC6LT8	7.8	34.0	43.7	51.7	58.2	57.8

Table V-6: Estimated Strong Hybrid Electric Vehicle (SHEV) Penetration Rate, Total Light-Duty Fleet

Model Year	2022	2027	2028	2029	2030	2031
No Action	6.9	22.3	22.8	24.4	24.0	23.3
PC2LT002	6.9	22.6	25.3	29.2	30.0	28.3
PC1LT3	6.9	24.9	29.8	35.1	36.8	35.0
PC2LT4	6.9	26.4	32.4	38.0	41.5	40.7
PC3LT5	6.9	26.6	32.8	39.4	44.1	45.2
PC6LT8	6.9	27.1	37.1	45.6	52.2	54.4

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[931] In this particular case, the higher stringencies of PC1LT3, PC2LT4, PC3LT5 and PC6LT8 lead to greater penetration of SHEV in Honda's fleet. At this greater level of tech penetration and tech investment in SHEV, the CAFE model projects that it becomes more cost effective for Honda to convert several of its CrV and TLX models to SHEV rather than convert additional models to PHEV, which is present only in the PC2LT002 altnernative during Honda's standard setting years, as making certain model lines within their fleet PHEVs are extremely constly. Specifically for Honda in PC2LT002, Honda is overcomplying with the CAFE standard, and the CAFE model applies PHEV tech in order to comply with GHG standards. At higher levels of stringency, SHEV tech is applied since it is a more cost-effective method of achieving fuel efficiency than PHEV.

Table V-7: Estimated Plug-in Hybrid-Electric Vehicle (PHEV) Penetration Rate, by Regulatory Fleet

Model Year	2022	2027	2028	2029	2030	2031
Passenger Car						
No Action	1.2	0.1	0.0	0.0	0.0	0.0
PC2LT002	1.2	1.6	1.5	1.5	1.4	1.3
PC1LT3	1.2	0.1	0.0	0.0	0.0	0.0
PC2LT4	1.2	0.1	0.0	0.0	0.0	0.0
PC3LT5	1.2	0.1	0.0	0.0	0.0	0.1
PC6LT8	1.2	0.1	0.0	0.0	0.0	0.1
Light Truck						
No Action	2.0	2.8	2.8	2.8	2.8	2.8
PC2LT002	2.0	4.9	4.9	4.9	4.9	7.9
PC1LT3	2.0	4.3	4.4	4.4	4.4	7.4
PC2LT4	2.0	4.3	4.4	4.4	4.4	7.4
PC3LT5	2.0	4.3	4.4	4.4	4.4	7.4
PC6LT8	2.0	4.3	4.4	4.4	4.4	7.4

Table V-8: Estimated Plug-in Hybrid-Electric Vehicle (PHEV) Penetration Rate, Total Light-Duty Fleet

Model Year	2022	2027	2028	2029	2030	2031
No Action	1.7	1.9	1.9	1.9	1.9	1.8
PC2LT002	1.7	3.8	3.8	3.8	3.7	5.7
PC1LT3	1.7	2.9	2.9	2.9	2.9	4.9
PC2LT4	1.7	2.9	2.9	2.9	2.9	4.9
PC3LT5	1.7	2.9	2.9	2.9	2.9	4.9
PC6LT8	1.7	2.9	2.9	2.9	2.9	4.9

Due to the statutory constraints imposed on the analysis by EPCA that exclude consideration of AFVs, BEVs are not a compliance option through model year 2031. Similarly, PHEVs can be introduced by the CAFE Model, but only their charge-sustaining fuel economy value is considered during standard setting years (as opposed to their charge-depleting fuel economy value, which is used in all other years). As seen in Table V–9 and Table V–10, BEV penetration increases across model years in the No-Action Alternative. During the standard setting years, BEVs are only added to account for manufacturers' expected response to state ZEV programs and additional electric vehicles that manufacturers have committed to deploy consistent with ACC II, regardless of whether it becomes legally binding. In model years *outside* of the standard setting restrictions, BEVs may be added if they are cost-effective to produce for reasons other than the CAFE standards The action alternatives show nearly the same BEV penetration rates as the No-Action Alternative during the standard setting years, although in some cases there is a slight deviation despite no new BEV models entering the fleet, due to rounding in some model years where fewer vehicles are being sold in response to the standards and altering fleet shares.

Table V-9: Estimated Battery Electric Vehicle (BEV) Penetration Rate, by Regulatory Fleet

Model Year	2022	2027	2028	2029	2030	2031
Passenger Car						
No Action	12.4	31.4	32.5	33.8	36.4	39.4
PC2LT002	12.4	31.4	32.5	33.8	36.4	39.4
PC1LT3	12.4	31.4	32.5	33.8	36.3	39.4
PC2LT4	12.4	31.4	32.5	33.8	36.3	39.3
PC3LT5	12.4	31.4	32.5	33.8	36.3	39.3
PC6LT8	12.4	31.4	32.5	33.8	36.3	39.3
Light Truck						
No Action	1.3	14.8	15.8	17.2	19.4	22.5
PC2LT002	1.3	14.8	15.8	17.2	19.4	22.5
PC1LT3	1.3	14.8	15.8	17.2	19.4	22.4
PC2LT4	1.3	14.8	15.8	17.2	19.4	22.4
PC3LT5	1.3	14.8	15.8	17.2	19.4	22.4
PC6LT8	1.3	14.8	15.8	17.2	19.4	22.4

Table V-10: Estimated Battery Electric Vehicle (BEV) Penetration Rate, Total Light-Duty Fleet

Model Year	2022	2027	2028	2029	2030	2031
No Action	5.5	20.5	21.5	22.8	25.1	28.1
PC2LT002	5.5	20.5	21.4	22.8	25.1	28.1
PC1LT3	5.5	20.5	21.5	22.8	25.2	28.2
PC2LT4	5.5	20.5	21.5	22.8	25.2	28.2
PC3LT5	5.5	20.5	21.5	22.8	25.2	28.2
PC6LT8	5.5	20.5	21.5	22.8	25.2	28.2

The FRIA provides a longer summary of NHTSA's estimates of manufacturers' potential application of fuel-saving technologies (including other types of technologies, such as advanced transmissions, aerodynamic improvements, and reduced vehicle mass) in response to each regulatory alternative. Appendices I and II of the accompanying FRIA provide more detailed and comprehensive results, and the underlying CAFE Model output files provide all the information used to construct these estimates, including the specific combination of technologies estimated to be applied to every vehicle model/configuration in each of model years 2022–2050.

NHTSA's analysis shows manufacturers' regulatory costs for compliance with the CAFE standards, combined with existing EPA GHG standards, state ZEV programs, and voluntary deployment of electric vehicles consistent with ACC II[932][933] unsurprisingly increasing more under the more stringent alternatives as more fuel-saving technologies would be required. As summarized in Table V–11, NHTSA estimates manufacturers' *cumulative* regulatory costs across model years 2027–2031 could total $148b under the No-Action Alternative, and an additional $18b, $21.8b, $33b, $41.4b, and $55.5b under alternatives PC2LT002, PC1LT3, PC2LT4, PC3LT5, and PC6LT8, respectively, when accounting for fuel-saving technologies added under the simulation for each regulatory alternative (including AC improvements and other off-cycle technologies), and also accounting for CAFE civil penalties that NHTSA estimates some manufacturers could elect to pay rather than achieving full compliance with the CAFE targets in

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[932] EPA's Multi-Pollutant Emissions Standards for Model Years 2027 and Later Light-Duty and Medium-Duty Vehicles were not modeled for this final rule.

[933] NHTSA does not model state GHG programs outside of the ZEV programs. See Chapter 2.2.2.6 of the accompanying TSD for details about how NHTSA models anticipated manufacturer compliance with California's ZEV program.

some model years in some fleets.[934] The table below shows how these costs are estimated to vary among manufacturers, accounting for differences in the quantities of vehicles produced for sale in the U.S. Differences in technology application and compliance pathways play a significant role in determining variation across aggregate manufacturer costs, and technology costs for each model year are defined on an incremental basis, with costs equal to the relevant technology applied minus the costs of the initial technology state in a reference fleet.[935] Appendices I and II of the accompanying FRIA present results separately for each manufacturer's passenger car and light truck fleets in each model year under each regulatory alternative, and the underlying CAFE Model output files also show results specific to manufacturers' domestic and imported car fleets.

Table V-11: Estimated Cumulative Technology Costs ($b) During MYs 2027-2031

Manufacturer	No Action	Relative to No Action				
		PC2LT002	PC1LT3	PC2LT4	PC3LT5	PC6LT8
BMW	3.6	0.1	0.1	0.1	0.2	0.3
Ford	20.3	2.8	7.7	8.0	8.0	7.9
General Motors	32.9	6.6	5.9	6.4	6.8	6.7
Honda	12.3	1.7	0.3	1.4	3.6	5.3
Hyundai	6.2	1.3	1.5	2.5	5.6	8.3
Jaguar - Land Rover	0.9	0.0	0.2	0.2	0.2	0.2
Kia	3.0	2.6	1.3	5.8	6.1	6.4
Karma	0.0	0.0	0.0	0.0	0.0	0.0
Lucid	0.0	0.0	0.0	0.0	0.0	0.0
Mazda	2.1	0.0	0.0	0.1	0.4	5.2
Mercedes-Benz	3.2	-0.1	0.0	0.0	0.0	0.0
Mitsubishi	1.6	0.0	0.0	0.0	0.1	0.6
Nissan	10.4	0.3	1.4	2.2	2.6	3.0
Rivian	0.0	0.0	0.0	0.0	0.0	0.0
Stellantis	24.5	2.8	2.9	3.5	3.8	3.7
Subaru	6.1	-0.2	-0.2	-0.1	0.5	2.7
Tesla	0.1	0.0	0.0	0.0	0.0	0.0
Toyota	15.5	-0.5	0.1	1.8	2.3	3.8
VWA	5.0	0.7	0.7	0.9	1.1	1.2
Volvo	0.6	0.0	0.1	0.1	0.1	0.2
Industry Total	148.4	18.0	21.8	33.0	41.4	55.5

As discussed in the TSD, these estimates reflect technology cost inputs that, in turn, reflect a ''markup'' factor that includes manufacturers' profits. In other words, if costs to manufacturers are reflected in vehicle price increases, NHTSA estimates that the average costs to new vehicle purchasers could increase through model year 2031 as summarized in Table V–12 and Table V–13. Table V–14 shows how these costs could vary among manufacturers, suggesting that price differences between manufacturers could increase as the stringency of standards increases. See Chapter 8.2.2 of the FRIA for more details of the effects on vehicle manufacturers, including compliance and regulatory costs.

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[934] Refer to Chapter 8.2.2 of the FRIA for more details on civil penalty payments by regulatory alternative.

[935] For more detail regarding the calculation of technology costs, see the CAFE Model Documentation.

Table V-12: Estimated Average Per-Vehicle Regulatory Cost ($), by Regulatory Fleet

Model Year	2022	2027	2028	2029	2030	2031
Passenger Car						
No Action	152	1,007	924	866	836	834
PC2LT002	152	1,143	1,151	1,264	1,249	1,191
PC1LT3	152	1,079	1,058	1,078	1,056	1,002
PC2LT4	152	1,135	1,202	1,337	1,342	1,284
PC3LT5	152	1,254	1,379	1,589	1,648	1,682
PC6LT8	152	1,544	1,996	2,516	2,872	3,137
Light Truck						
No Action	119	1,277	1,257	1,249	1,263	1,308
PC2LT002	119	1,403	1,432	1,473	1,534	1,718
PC1LT3	119	1,503	1,666	1,772	1,906	2,144
PC2LT4	119	1,553	1,795	1,942	2,302	2,585
PC3LT5	119	1,608	1,903	2,111	2,658	3,039
PC6LT8	119	1,818	2,353	2,829	3,735	4,373

Table V-13: Estimated Average Per-Vehicle Regulatory Cost ($), Total Light-Duty Fleet

Model Year	2022	2027	2028	2029	2030	2031
No Action	132	1,185	1,144	1,120	1,119	1,149
PC2LT002	132	1,314	1,338	1,403	1,439	1,541
PC1LT3	132	1,358	1,460	1,537	1,618	1,756
PC2LT4	132	1,410	1,594	1,738	1,975	2,141
PC3LT5	132	1,487	1,726	1,935	2,314	2,575
PC6LT8	132	1,725	2,233	2,724	3,441	3,951

Table V-14: Average Manufacturer Per-Vehicle Costs by Alternative, Total Light-Duty Fleet, MY 2031 ($)

Manufacturer	No Action	PC2LT002	PC1LT3	PC2LT4	PC3LT5	PC6LT8
BMW	1,286	1,303	1,402	1,456	1,579	1,722
Ford	982	1,382	1,986	2,007	2,020	2,020
General Motors	1,930	3,466	3,328	3,454	3,653	3,693
Honda	985	1,127	988	1,184	1,475	1,785
Hyundai	875	1,218	1,327	1,551	3,153	3,741
Jaguar - Land Rover	752	881	3,166	3,178	3,169	3,169
Karma	-4,776	-4,776	-4,776	-4,776	-4,776	-4,776
Kia	716	1,850	1,412	4,340	4,643	4,981
Lucid	0	0	0	0	0	0
Mazda	1,436	1,436	1,436	1,593	1,981	8,170
Mercedes-Benz	1,561	1,561	1,561	1,561	1,584	1,654
Mitsubishi	1,154	1,246	1,176	1,353	1,630	2,708
Nissan	1,238	1,362	1,552	1,879	2,088	2,327
Rivian	0	0	0	0	0	0
Stellantis	1,475	1,866	1,920	1,995	2,041	2,041
Subaru	1,227	1,227	1,227	1,227	1,421	2,277
Tesla	15	15	15	15	15	15
Toyota	928	928	932	1,151	1,327	1,659
Volvo	115	257	474	579	593	652
VWA	1,042	1,370	1,470	1,565	1,635	1,695
Industry Average	1,149	1,524	1,604	1,857	2,097	2,392

Fuel savings and regulatory costs act as competing forces on new vehicle sales. All else being equal, as fuel savings increase, the CAFE Model projects higher new vehicle sales, but as regulatory costs increase, the CAFE Model projects lower new vehicle sales. Both fuel savings and regulatory costs increase with stringency. NHTSA observed that on net that regulatory costs were increasing faster than the first 30 months of fuel savings in the CAFE Model projections and as such, sales decreased in higher stringency alternatives. The magnitude of these fuel savings and vehicle price increases depends on manufacturer compliance decisions, especially technology application. In the event that manufacturers select technologies with lower prices and/or higher fuel economy improvements, vehicle sales effects could differ. TSD Chapter 4.2.1.2 discusses NHTSA's approach to estimating new vehicle sales, including NHTSA's estimate that new vehicle sales could recover from 2020's aberrantly low levels. Figure V–1 shows the estimated annual light-duty industry sales by regulatory alternative. For all scenarios, sales stay constant relative to the No-Action scenario through model year 2026, after which the model begins applying technology in response to the action alternatives. Excluding the most stringent case, light-duty vehicle sales differ from the No-Action Alternative by approximately 1 percent or less through model year 2050, and PC6LT8 sales differ from the No-Action Alternative by less than 2.5 percent through model year 2050.

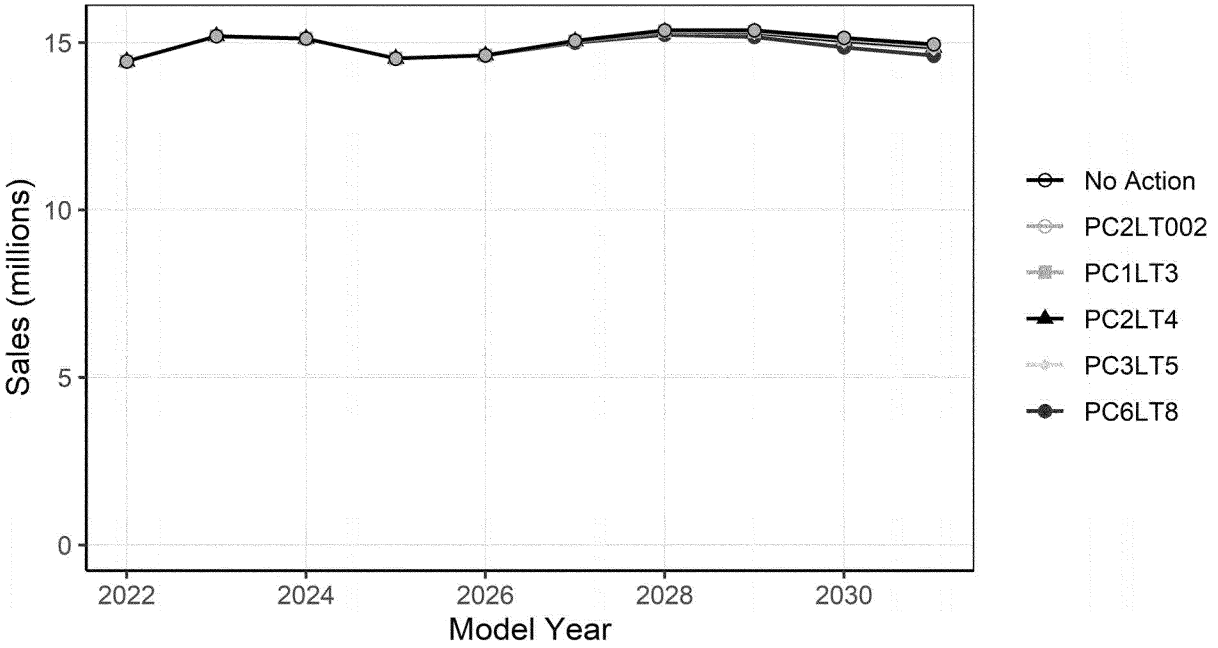

Figure V-1: Estimated Annual Light-Duty Vehicle Sales (Millions)

These slight reductions in new vehicle sales tend to reduce projected automobile industry labor projections by small margins. NHTSA estimates that the cost increases could reflect an underlying increase in employment to produce additional fuel-saving technology, such that automobile industry labor could remain relatively similar under each of the five regulatory alternatives.

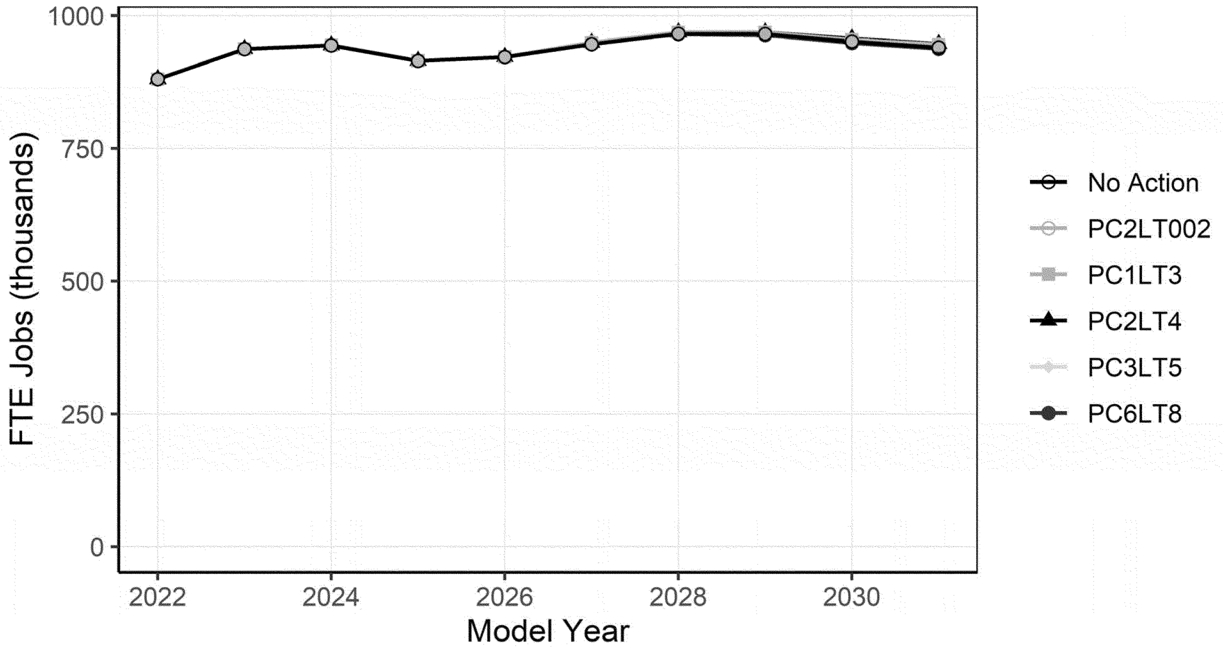

Figure V-2: Estimated Light-Duty Automobile Industry Labor as Thousands of Full-Time-Equivalent Jobs

The accompanying TSD Chapter 6.2.5 discusses NHTSA's approach to estimating automobile industry employment, and the accompanying FRIA Chapter 8.2 (and its Appendices I and II) and CAFE Model output files provide more detailed results of NHTSA's light-duty analysis.

We also include in the analysis a No ZEV alternative baseline, wherein some sales volumes *do not* in MYs 2023 and beyond turn into ZEVs in accordance with OEM commitments to deploy additional electric vehicles consistent with ACC II, regardless of whether it becomes legally binding. The No ZEV alternative baseline still includes BEVs and PHEVs, but they are those that were already observed in the MY 2022 analysis fleet, as well as any made by the model outside of standard setting years for LD BEVs (or in all years, in the case of PHEVs and HDPUV BEVs). Across the entire light-duty fleet, the technology penetration rates differ mainly from 2027 onwards. In the reference baseline, BEVs make up approximately 28 percent of the total light-duty fleet by model year 2031; they make up only 19 percent of the total light-duty fleet by 2031 in the No ZEV alternative baseline.

PHEVs have virtually the same tech penetration in the reference baseline as in the no ZEV alternative baseline, as the CAFE Model does not *build* PHEVs for ZEV program compliance (only counts PHEVs built for other reasons towards ZEV program compliance) or deploy them based on OEM commitments to deploy electric vehicles consistent with ACC II. PHEVs increase only from 2 percent in the reference case to 3 percent in the No ZEV alternative baseline by model year 2031. Strong hybrids have a slightly higher tech penetration rate under the reference baseline than in the No ZEV case in model years between 2027 and 2031 at 27 percent compared to 23 percent in the reference baseline in model year 2031.

2. Heavy-Duty Pickups and Vans

Each of the regulatory alternatives considered represents an increase in HDPUV fuel efficiency standards for model years 2030–2035 relative to the existing standards set in 2016, with increases in efficiency each year through model year 2035. Unlike the light-duty CAFE program, NHTSA may consider AFVs when setting maximum feasible average standards for HDPUVs. Additionally, for purposes of calculating average fuel efficiency for HDPUVs, NHTSA considers EVs, fuel cell vehicles, and the proportion of electric operation of EVs and PHEVs that is derived from electricity that is generated from sources that are not onboard the vehicle to have a fuel efficiency value of 0 gallons/mile.

NHTSA recognizes that it is possible that the size and composition of the fleet (*i.e.,* in terms of vehicle attributes that impact calculation of standards for averaging sets) could change over time, which would affect the currently-estimated average fuel efficiency requirements. If fleet changes ultimately differ from NHTSA's projections, average requirements could, therefore, also differ from NHTSA's projections. The table below includes the estimated required average fuel efficiency values for the HDPUV fleet in each of the regulatory alternatives considered in this final rule.

Table V-15: Estimated Required Average Fuel Efficiency (gal/100mi), Total HDPUV Fleet

Model Year	2022	2030	2031	2032	2033	2034	2035
No Action	5.575	5.000	5.027	5.027	5.027	5.026	5.023
HDPUV4	5.575	4.796	4.632	4.446	4.268	4.097	3.931
HDPUV108	5.575	4.503	4.074	3.667	3.373	3.102	2.851
HDPUV10	5.575	4.503	4.074	3.667	3.294	2.964	2.664
HDPUV14	5.575	4.292	3.707	3.188	2.724	2.342	2.012

As with the light-duty program, manufacturers do not always comply exactly with each fuel efficiency standard in each model year. Manufacturers may bank credits from overcompliance in one year that may be used to cover shortfalls in up to five future model years. Manufacturers may also carry forward credit deficits for up to three model years. If a manufacturer is still unable to address the shortfall, NHTSA may assess civil penalties. As discussed in the accompanying FRIA and TSD, NHTSA simulates manufacturers' responses to each alternative given a wide range of input estimates (*e.g.,* technology cost and effectiveness, fuel prices, electrification technologies). For this final rule, NHTSA estimates that manufacturers' responses to standards defined in each alternative could lead average fuel efficiency levels to improve through model year 2035, as shown in the following tables.

Table V-16: Estimated Achieved Average Fuel Efficiency (gal/100mi), Total HDPUV Fleet

Model Year	2022	2030	2031	2032	2033	2034	2035
No Action	5.896	3.404	2.742	2.742	2.737	2.732	2.716
HDPUV4	5.896	3.382	2.736	2.735	2.730	2.725	2.710
HDPUV108	5.896	3.421	2.759	2.758	2.603	2.598	2.565
HDPUV10	5.896	3.421	2.759	2.758	2.481	2.477	2.431
HDPUV14	5.896	3.352	2.641	2.641	2.028	2.023	1.954

Table V–16 displays the projected achieved FE levels for the HDPUV fleet through model year 2035. Estimates of achieved levels are very similar between the No-Action Alternative and the least stringent action alternative, with even the most stringent action alternative differing by less than 0.8 gallons/100 miles from the No-Action Alternative. The narrow band of estimated average achieved levels in Table V–16 is primarily due to several factors. Relative to the LD fleet, the HDPUV fleet (i) represents a smaller number of vehicles, (ii) includes fewer manufacturers, and (iii) is composed of a smaller number of manufacturer product lines. Technology choices for an individual manufacturer or individual product line can therefore have a large effect on fleet-wide average fuel efficiency. Second, Table V–17 shows that in the No-Action Alternative a substantial portion of the fleet converts to an electrified powertrain (*e.g.,* SHEV, PHEV, BEV) between model year 2022 and model year 2030. This reduces the availability of, and need for,[936] additional fuel efficiency improvement to meet more stringent standards.

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[936] The need for further improvements in response to more stringent HDPUV standards is further reduced by the fact that NHTSA regulations currently grant BEVs (and the electric-only operation of PHEVs) an HDPUV compliance value of 0 gallons/100 miles.

Table V-17: Application Levels of Selected Technologies by Model Year for HDPUV Fleet

	2022	2030	2031	2032	2033	2034	2035	2036	2037	2038
Technology Application Levels in the No-Action Alternative										
Strong Hybrid (all types)	0%	27%	38%	38%	38%	38%	38%	38%	38%	37%
PHEV (all types)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
BEV (all types)	0%	27%	37%	37%	38%	38%	38%	38%	38%	40%
Advanced Engines	0%	34%	23%	23%	23%	23%	23%	23%	23%	22%
Technology Application Levels in the Action Alternatives										
HDPUV4										
Strong Hybrid (all types)	0%	27%	38%	38%	38%	38%	38%	38%	38%	37%
PHEV (all types)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
BEV (all types)	0%	28%	38%	38%	38%	38%	38%	38%	39%	41%
Advanced Engines	0%	34%	24%	24%	24%	24%	23%	23%	23%	22%
HDPUV108										
Strong Hybrid (all types)	0%	27%	38%	38%	37%	37%	37%	37%	37%	36%
PHEV (all types)	0%	0%	0%	0%	4%	4%	4%	4%	4%	4%
BEV (all types)	0%	27%	37%	37%	37%	37%	38%	38%	38%	40%
Advanced Engines	0%	34%	24%	24%	20%	20%	20%	20%	20%	19%
HDPUV10										
Strong Hybrid (all types)	0%	27%	38%	38%	37%	37%	37%	37%	37%	36%
PHEV (all types)	0%	0%	0%	0%	6%	6%	6%	6%	6%	6%
BEV (all types)	0%	27%	37%	37%	38%	38%	39%	39%	40%	41%
Advanced Engines	0%	34%	24%	24%	18%	18%	18%	18%	17%	17%
HDPUV14										
Strong Hybrid (all types)	0%	27%	38%	38%	33%	33%	33%	33%	33%	32%
PHEV (all types)	0%	0%	0%	0%	12%	12%	13%	13%	12%	12%
BEV (all types)	0%	28%	39%	39%	43%	44%	44%	44%	44%	46%
Advanced Engines	0%	34%	22%	22%	12%	12%	10%	10%	10%	10%

Note: "advanced engines" represents the combined penetration of advanced cylinder deactivation, advanced turbo, variable compression ratio, high compression ratio, and diesel engines.[937]

In line with the technology application trends above, regulatory costs do not differ by large amounts between the No-Action Alternative and the action alternatives. The largest differences in regulatory costs occur in the HDPUV14 alternative and are also concentrated in a few manufacturers (*e.g.,* Ford, GM), where the compliance modeling projects increases in PHEV and advanced engine technologies. For example, GM is projected to increase its turbo parallel engine technology penetration by 2038, which is modeled as a lower cost than the superseded advanced diesel engine technology in the reference baseline, contributing to the negative cost in the No-Action Alternative. See RIA Chapter 8.3.2 for more detail on the manufacturer regulatory cost by action alternative.

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[937] Specifically, this includes technologies with the following codes in the CAFE Model: TURBO0, TURBOE, TURBOD, TURBO1, TURBO2, ADEACD, ADEACS, HCR, HRCE, HCRD, VCR, VTG, VTGE, TURBOAD, ADSL, DSLI.

Table V-18: Estimated Total Regulatory Cost by Manufacturer ($b), MY 2022-2038

Manufacturer	No Action	Relative to No Action			
		HDPUV4	HDPUV108	HDPUV10	HDPUV14
Ford	7.27	0.25	-0.12	0.33	2.41
GM	-1.90	-0.12	1.55	2.25	4.52
Mercedes-Benz	0.09	0.00	0.00	0.00	0.02
Nissan	1.04	0.00	0.00	0.00	0.02
Stellantis	2.76	0.00	0.00	0.00	0.00
Total	9.26	0.13	1.43	2.58	6.97

On a per-vehicle basis, costs by 2033 increase progressively with stringency. Average per-vehicle costs are estimated to decrease slightly for alternatives HDPUV108 and HPUV10 relative to the No-Action Alternative for model year 2030–2032. Cost reductions of technology applied in these years, combined with shifts altering the combination of technologies to comply with different stringencies, result in negative regulatory costs relative to the No-Action Alternative. Specifically, differences in the quantity and type of technology applications in the compliance pathways contribute to the cost variation across regulatory alternatives.[938] Overall, the two least stringent alternatives represent less than a 12 percent difference in average per-vehicle cost compared to the No-Action Alternative. FRIA Chapter 8.3.2.1 provides more information about the technology penetration changes and the subsequent costs.

Table V-19: Estimated Average Per-Vehicle Regulatory Cost ($), Total HDPUV Fleet

		2022	2030	2031	2032	2033	2034	2035
No Action		0	1267	1330	1080	831	592	374
Relative to No Action	HDPUV4	0	0	36	8	9	8	8
	HDPUV108	0	-30	-27	-23	253	241	247
	HDPUV10	0	-30	-27	-23	450	426	436
	HDPUV14	0	96	183	170	1136	1059	1071

The sales and labor markets are estimated to have relatively little variation in impacts across the No-Action Alternative and action alternatives. The increase in sales in the No-Action Alternative carries over to each of the action alternatives as well. The vehicle-level cost increases noted above in Table V–19 produce very small declines in overall sales. With the exception of HDPUV14, the change in sales across alternatives stays within about a 0.21 percent change relative to the No-Action Alternative, and HDPUV14 stays within a 0.6 percent change relative to the No-Action Alternative.

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[938] Manufacturers overcomplying with the least stringent standard can lead the CAFE model to applying additional cost-effective technology adjustments which may increase the average regulatory cost. As the stringency increases, the CAFE model follows the cost-effective compliance path which may be limited in terms of manufacturer refresh/redesign schedules. In the HDPUV4 scenario, Ford is modeled to transition more towards BEV rather than strong hybrids, which results in an increased average cost over the reference scenario. In the HDPUV108 and HDPUV10 scenarios, a redesign in 2030 is projected to lead to more lower level engine technology and fewer overall tech changes compared to HDPUV4, which contribute to the negative average cost for several years but a larger jump in costs in later years.

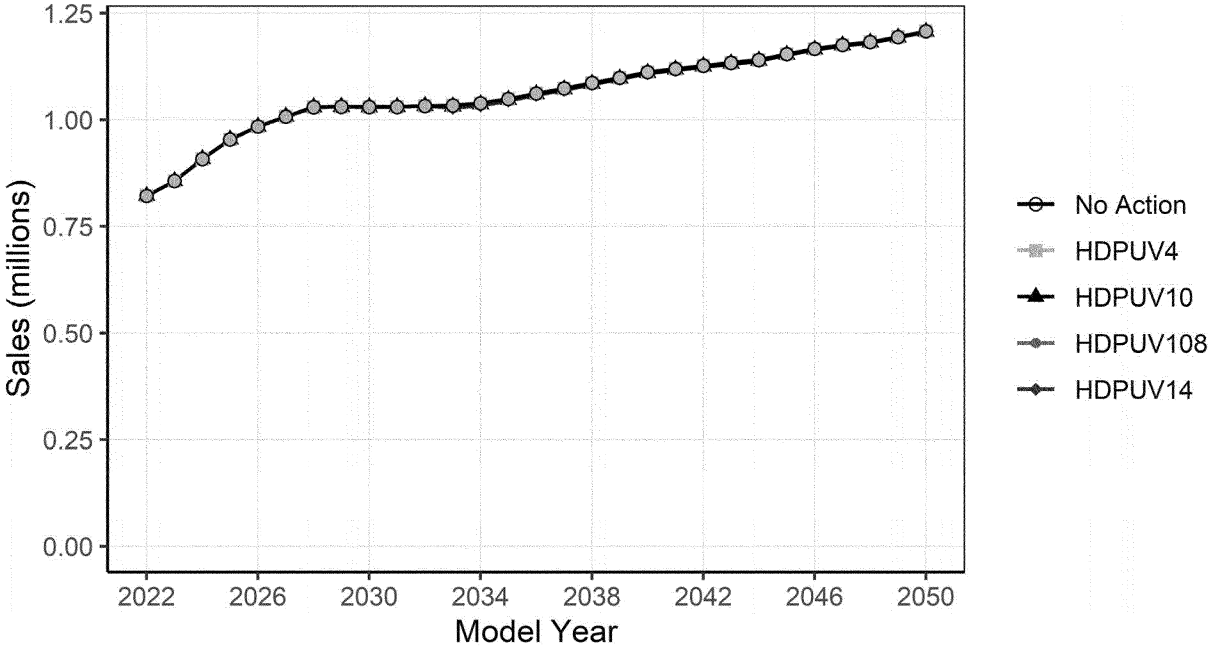

Figure V-3: Estimated Annual New HDPUV Vehicle Sales (Millions)

These minimal sales declines and limited additional technology application produce small decreases in labor utilization, as the sales effect ultimately outweighs job gains due to development and application of advanced technology. In aggregate, the alternatives represent less than half of a percentage point deviation from the No-Action Alternative.

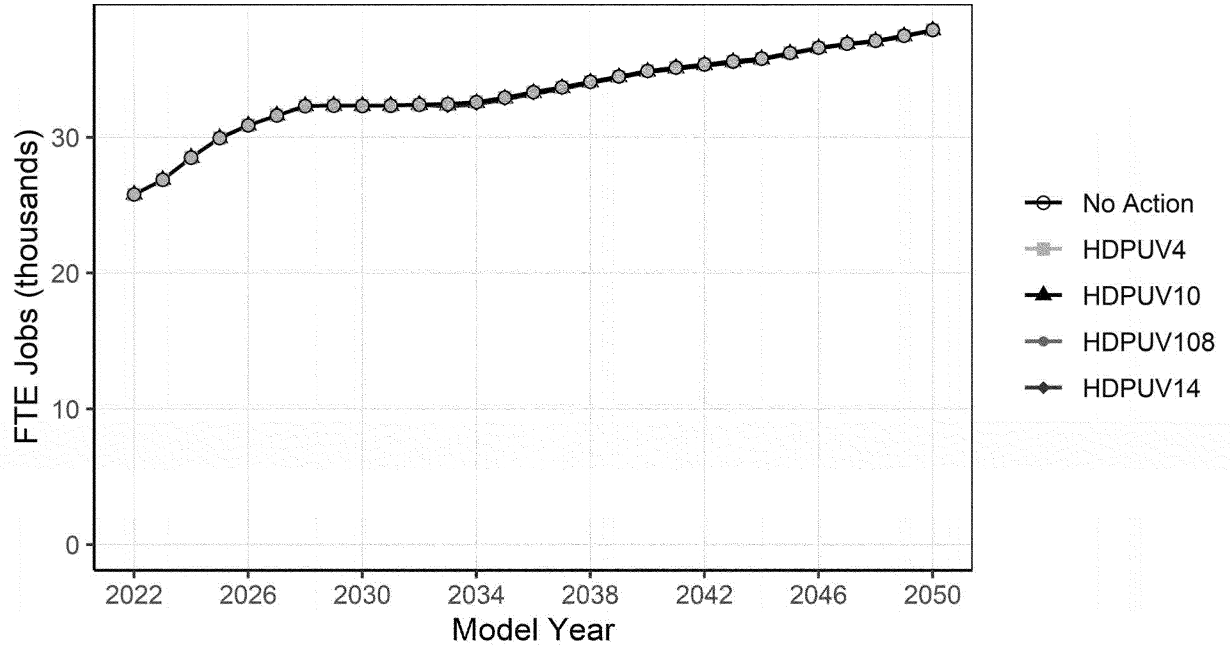

Figure V-4: Estimated HDPUV Automobile Industry Labor (as Thousands of Full-Time-Equivalent Jobs)

The accompanying TSD Chapter 6.2.5 discusses NHTSA's approach to estimating automobile industry employment, and the accompanying FRIA Chapter 8.3.2.3 (and its Appendix III) and CAFE Model output files provide more detailed results of NHTSA's HDPUV analysis.

B. Effects on Society

NHTSA accounts for the effects of the standards on society using a benefit-cost framework. The categories considered include private costs borne by manufacturers and passed on to consumers, social costs, which include Government costs and externalities pertaining to emissions, congestion, noise, energy security, and safety, and all the benefits resulting from related categories in the form of savings, however they may occur across the presented alternatives. In this accounting framework, the CAFE Model records costs and benefits for vehicles in the fleet throughout the lifetime of a particular model year and also allows for the accounting of costs and benefits by calendar years. Examining program effects through this lens illustrates the temporal differences in major cost and benefit components and allows us to examine costs and benefits for only those vehicles that are directly regulated by the standards. In the HDPUV FE analysis, where the standard would continue until otherwise amended, we report only the costs and benefits across calendar years.

1. Passenger Cars and Light Trucks

We split effects on society into private costs, social costs, private benefits, and external benefits. Table V–21 and Table V–22 describe the costs and benefits of increasing CAFE standards in each alternative, as well as the party to which they accrue. Manufacturers are directly regulated under the program and incur additional production costs when they apply technology to their vehicle offerings in order to improve their fuel economy. We assume that those costs are fully passed through to new car and truck buyers in the form of higher prices. We also assume that any civil penalties paid by manufacturers for failing to comply with their CAFE standards are passed through to new car and truck buyers and are included in the sales price. However, those civil penalties are paid to the U.S. Treasury, where they currently fund the general business of government. As such, they are a transfer from new vehicle buyers to all U.S. citizens, who then benefit from the additional Federal revenue. While they are calculated in the analysis, and do influence consumer decisions in the marketplace, they do not directly contribute to the calculation of net benefits (and are omitted from the tables below).

While incremental maintenance and repair costs and benefits would accrue to buyers of new cars and trucks affected by more stringent CAFE standards, we do not carry these impacts in the analysis. They are difficult to estimate but represent real costs (and potential benefits in the case of AFVs that require less frequent maintenance events). They may be included in future analyses as data become available to evaluate lifetime maintenance impacts. This analysis assumes that drivers of new vehicles internalize 90 percent of the risk associated with increased exposure to crashes when they engage in additional travel (as a consequence of the rebound effect).

Private benefits are dominated by the value of fuel savings, which accrue to new car and truck buyers at retail fuel prices (inclusive of Federal and state taxes). In addition to saving money on fuel purchases, new vehicle buyers also benefit from the increased mobility that results from a lower cost of driving their vehicle (higher fuel economy reduces the per-mile cost of travel) and fewer refueling events. The additional travel occurs as drivers take advantage of lower operating costs to increase mobility, and this generates benefits to those drivers—equivalent to the cost of operating their vehicles to travel those miles, the consumer surplus, and the offsetting benefit that represents 90 percent of the additional safety risk from travel.

In addition to private benefits and costs—those borne by manufacturers, buyers, and owners of cars and light trucks—there are other benefits and costs from increasing CAFE standards that are borne more broadly throughout the economy or society, which NHTSA refers to as social costs.[939] The additional driving that occurs as new vehicle buyers take advantage of lower per-mile fuel costs is a benefit to those drivers, but the congestion (and road noise) created by the additional travel also imposes a small additional social cost to all road users. We also include transfers from one party to another other than those directly incurred by manufacturers or new vehicle buyers with social costs, the largest of which is the loss in fuel tax revenue that occurs as a result of falling fuel consumption.[940] Buyers of new cars and light trucks produced in model years subject to increasing CAFE standards save on fuel purchases that include Federal, state, and sometimes local taxes, so revenues from these taxes decline; because that revenue funds maintenance of roads and bridges as well as other government activities, the loss in fuel tax revenue represents a social cost, but is offset by the benefits gained by drivers who spend less at the pump.[941]

Among the purely external benefits created when CAFE standards are increased, the largest is the reduction in damages resulting from GHG emissions. Table V–20 shows the different social cost results that correspond to each GHG discount rate. The associated benefits related to reduced health damages from criteria pollutants and the benefit of improved energy security are both significantly smaller than the associated change in GHG damages across alternatives. As the tables also illustrate, the majority of costs are private costs that accrue to buyers of new cars and trucks, but the plurality of benefits stem from external welfare changes that affect society more generally. These external benefits are driven mainly by the benefits from reducing GHGs.

The tables show that the social and SC–GHG discount rates have a significant impact on the estimated benefits in terms of magnitudes. Net social benefits are positive for all alternatives at both the 3 percent and 7 percent social discount rates but have higher magnitudes under the lower SC–GHG discount rates. Net benefits are higher when assessed at a 3 percent social discount rate since the largest benefit—fuel savings—accrues over a prolonged period, while the largest cost—technology costs—accrue predominantly in earlier years. Totals in the following table may not sum perfectly due to rounding.

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[939] Some of these external benefits and social costs result from changes in economic and environmental externalities from supplying or consuming fuel, while others do not involve changes in such externalities but are similar in that they are borne by parties other than those whose actions impose them.

[940] Changes in tax revenues are a transfer and not an economic externality as traditionally defined, but we group these with social costs instead of private costs since that loss in revenue affects society as a whole as opposed to impacting only consumers or manufacturers.

[941] It may subsequently be replaced by another source of revenue, but that is beyond the scope of this final rule to examine.

Table V-20: Incremental Benefits and Costs Over the Lifetimes of Total LD Fleet Produced Through MY 2031 (2021$ Billions), by Alternative

	3% Discount Rate					7% Discount Rate				
	PC2 LT002	**PC1 LT3**	**PC2 LT4**	**PC3 LT5**	**PC6 LT8**	**PC2 LT002**	**PC1 LT3**	**PC2 LT4**	**PC3 LT5**	**PC6 LT8**
Private Costs										
Technology Costs to Increase Fuel Economy	14.0	16.9	25.6	32.0	43.0	10.2	12.3	18.5	23.1	31.1
Increased Maintenance and Repair Costs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sacrifice in Other Vehicle Attributes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Consumer Surplus Loss from Reduced New Vehicle Sales	0.0	0.0	0.1	0.2	0.7	0.0	0.0	0.0	0.1	0.5
Safety Costs Internalized by Drivers	2.7	4.3	5.7	6.5	8.0	1.5	2.4	3.2	3.6	4.5
Subtotal - Private Costs	16.8	21.3	31.3	38.7	51.7	11.7	14.7	21.7	26.9	36.0
Social Costs										
Congestion and Noise Costs from Rebound-Effect Driving	2.1	3.0	4.7	6.5	8.4	1.2	1.8	2.8	3.7	5.0
Safety Costs Not Internalized by Drivers	1.4	1.8	4.0	7.2	11.9	0.9	1.3	2.6	4.5	7.9
Loss in Fuel Tax Revenue	4.2	5.7	7.0	7.6	8.7	2.4	3.2	4.0	4.3	4.9
Subtotal - Social Costs	7.7	10.5	15.7	21.4	29.0	4.5	6.3	9.3	12.5	17.8
Total Societal Costs (incl. private)	24.5	31.8	47.1	60.1	80.8	16.2	21.0	31.0	39.4	53.8
Private Benefits										
Reduced Fuel Costs	21.4	32.3	40.7	44.8	52.0	12.0	18.1	22.8	25.0	28.9
Benefits from Additional Driving	4.3	6.9	9.0	10.3	12.4	2.4	3.9	5.1	5.8	6.9
Less Frequent Refueling	1.3	1.7	2.2	2.5	3.1	0.8	1.0	1.2	1.4	1.8
Subtotal - Private Benefits	27.0	41.0	51.9	57.6	67.5	15.2	22.9	29.1	32.2	37.5
External Benefits										
Reduction in Petroleum Market Externality	1.0	1.4	1.7	1.8	2.1	0.6	0.8	0.9	1.0	1.2
Reduced Health Damages	0.7	0.8	0.8	0.7	0.6	0.4	0.4	0.4	0.3	0.2
Reduced Climate Damages										
SC-GHG at 2.5% DR	18.3	25.4	31.4	34.3	39.5	18.3	25.4	31.4	34.3	39.5
SC-GHG at 2.0% DR	30.9	42.7	52.8	57.7	66.5	30.9	42.7	52.8	57.7	66.5

SC-GHG at 1.5% DR	54.4	75.3	93.0	101.6	117.2	54.4	75.3	93.0	101.6	117.2
Total Societal Benefits (incl. private)										
SC-GHG at 2.5% DR	47.1	68.5	85.7	94.4	109.6	34.5	49.4	61.7	67.9	78.4
SC-GHG at 2.0% DR	59.7	85.8	107.2	117.8	136.6	47.0	66.8	83.1	91.3	105.4
SC-GHG at 1.5% DR	83.2	118.4	147.4	161.8	187.3	70.5	99.3	123.4	135.2	156.1
Net Social Benefits										
SC-GHG at 2.5% DR	22.7	36.7	38.7	34.3	28.8	18.2	28.4	30.7	28.5	24.6
SC-GHG at 2.0% DR	35.2	54.0	60.1	57.7	55.8	30.8	45.8	52.1	51.9	51.6
SC-GHG at 1.5% DR	58.7	86.6	100.3	101.7	106.6	54.3	78.3	92.3	95.8	102.3

Table V-21 Incremental Benefits and Costs for the On-Road LD Fleet CY 2022-2050

(2021$ Billions), by Alternative

	3% Discount Rate					**7% Discount Rate**				
	PC2 LT002	**PC1 LT3**	**PC2 LT4**	**PC3 LT5**	**PC6 LT8**	**PC2 LT002**	**PC1 LT3**	**PC2 LT4**	**PC3 LT5**	**PC6 LT8**
Private Costs										
Technology Costs to Increase Fuel Economy	43.1	63.4	107.3	158.4	233.9	26.7	37.6	62.1	89.6	131.1
Increased Maintenance and Repair Costs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sacrifice in Other Vehicle Attributes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Consumer Surplus Loss from Reduced New Vehicle Sales	0.0	0.0	0.2	0.4	1.6	0.0	0.0	0.1	0.3	1.0
Safety Costs Internalized by Drivers	9.7	15.8	20.8	25.6	33.5	4.8	7.7	10.1	12.4	16.1
Subtotal - Private Costs	52.9	79.3	128.3	184.4	269.0	31.5	45.3	72.3	102.2	148.2
Social Costs										
Congestion and Noise Costs from Rebound-Effect Driving	6.3	10.4	13.6	16.7	21.7	3.1	5.2	6.8	8.3	10.7
Safety Costs Not Internalized by Drivers	1.4	1.5	2.6	3.8	9.8	0.8	1.0	1.7	2.6	6.1
Loss in Fuel Tax Revenue	16.2	24.1	31.4	38.5	52.4	8.1	11.9	15.5	18.8	25.4
Subtotal - Social Costs	23.9	36.0	47.6	59.0	83.9	12.1	18.1	24.0	29.7	42.2
Total Societal Costs (incl. private)	76.8	115.3	175.8	243.4	352.9	43.6	63.4	96.3	131.9	190.4
Private Benefits										
Reduced Fuel Costs	82.0	129.5	169.5	207.0	280.7	40.6	63.5	83.0	100.9	135.5
Benefits from Additional Driving	15.2	24.9	32.5	39.6	50.9	7.5	12.1	15.9	19.3	24.6
Less Frequent Refueling	2.3	-0.4	-0.6	-2.7	-0.5	1.3	0.0	0.0	-0.9	0.1
Subtotal - Private Benefits	99.5	154.0	201.3	243.9	331.1	49.4	75.6	98.8	119.3	160.3
External Benefits										

Reduction in Petroleum Market Externality	4.2	6.2	8.1	9.9	13.6	2.1	3.0	3.9	4.8	6.5
Reduced Health Damages	4.0	5.7	7.3	9.3	12.2	1.7	2.4	3.1	3.9	5.1
Reduced Climate Damages										
SC-GHG at 2.5% DR	76.5	116.2	151.6	186.2	254.6	76.5	116.2	151.6	186.2	254.6
SC-GHG at 2% DR	129.2	196.4	256.3	314.8	430.6	129.2	196.4	256.3	314.8	430.6
SC-GHG at 1.5% DR	228.5	347.4	453.4	556.9	762.2	228.5	347.4	453.4	556.9	762.2
Total Societal Benefits (incl. private)										
SC-GHG at 2.5% DR	184.2	282.0	368.4	449.3	611.5	129.7	197.2	257.5	314.2	426.5
SC-GHG at 2% DR	236.9	362.2	473.0	577.9	787.5	182.4	277.4	362.1	442.7	602.5
SC-GHG at 1.5% DR	336.2	513.3	670.1	820.0	1,119.1	281.6	428.5	559.2	684.8	934.0
Net Social Benefits										
SC-GHG at 2.5% DR	107.4	166.8	192.5	205.9	258.6	86.1	133.9	161.2	182.2	236.1
SC-GHG at 2% DR	160.1	247.0	297.1	334.4	434.6	138.8	214.1	265.8	310.7	412.1
SC-GHG at 1.5% DR	259.3	398.0	494.2	576.5	766.2	238.0	365.1	462.9	552.9	743.6

Our analysis also includes a No ZEV alternative baseline for light-duty, and the CAFE Model outputs results for all scenarios relative to that baseline as well. Net benefits in the preferred alternative increase when viewing the analysis from the perspective of the No ZEV alternative baseline. Using the model year perspective, the SC–GHG DR of 2% and a social discount rate of 3%, net benefits in the preferred alternative of the No ZEV alternative baseline are 44.9 billion, compared to the preferred alternative's net benefits relative to the reference baseline (35.2 billion).

2. Heavy-Duty Pickups and Vans

Our categorizations of benefits and costs in the HDPUV space mirrors the approach taken above for light-duty passenger trucks and vans. Table V–22 describes the costs and benefits of increasing standards in each alternative, as well as the party to which they accrue. Manufacturers are directly regulated under the program and incur additional production costs when they apply technology to their vehicle offerings in order to improve their fuel efficiency. We assume that those costs are fully passed through to new HDPUV buyers, in the form of higher prices.

One key difference between the light-duty and HDPUV analysis is how the agency approaches VMT. As explained in more detail in III.E.3 and TSD Chapter 4.3, the agency does not constrain non-rebound VMT. As a result, decreasing sales in the HDPUV fleet will lower the amount of total VMT, while the rebound effect will cause those vehicles that are improved and sold, to be driven more. On net, the CAFE Model shows that the amount of VMT forgone from lower sales slightly outweighs the amount of VMT gained through rebound driving, and as a result some of the externalities from driving, such as safety costs and congestion, appear as a cost reduction relative to the No-Action Alternative.

The choice of GHG discount rate also affects the resulting benefits and costs. As the tables show, net social benefits are positive for all alternatives, and are greatest when the SC–GHG discount rate of 1.5 percent is used. Totals in the following table may not sum perfectly due to rounding.

Table V-22: Incremental Benefits and Costs for the On-Road HDPUV Fleet CY 2022-2050 (2021$ Billions), by Alternative

	3% Discount Rate				7% Discount Rate			
Alternative	**HDPUV 4**	**HDPUV 108**	**HDPUV 10**	**HDPUV 14**	**HDPUV 4**	**HDPUV 108**	**HDPUV 10**	**HDPUV 14**
Private Costs								
Technology Costs to Increase Fuel Economy	0.12	2.33	3.74	8.75	0.07	1.12	1.83	4.46
Increased Maintenance and Repair Costs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sacrifice in Other Vehicle Attributes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Consumer Surplus Loss from Reduced New Vehicle Sales	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
Safety Costs Internalized by Drivers	0.01	0.11	0.22	0.43	0.00	0.05	0.09	0.19
Subtotal - Private Costs	0.13	2.44	3.96	9.18	0.07	1.16	1.92	4.65
Social Costs								
Congestion and Noise Costs	0.00	-0.07	-0.09	-0.23	0.00	-0.03	-0.04	-0.10
Safety Costs Not Internalized by Drivers	0.00	-0.25	-0.40	-0.89	0.00	-0.10	-0.16	-0.38
Loss in Fuel Tax Revenue	0.11	1.28	2.15	5.71	0.05	0.55	0.94	2.57
Subtotal - Social Costs	0.11	0.96	1.67	4.59	0.05	0.42	0.74	2.09
Total Social Costs	0.24	3.40	5.62	13.77	0.12	1.58	2.66	6.74
Private Benefits								
Reduced Fuel Costs	0.40	4.94	8.38	21.25	0.19	2.11	3.65	9.49

	3% Discount Rate				**7% Discount Rate**			
Alternative	**HDPUV 4**	**HDPUV 108**	**HDPUV 10**	**HDPUV 14**	**HDPUV 4**	**HDPUV 108**	**HDPUV 10**	**HDPUV 14**
Benefits from Additional Driving	0.01	0.22	0.43	0.79	0.00	0.09	0.19	0.35
Less Frequent Refueling	-0.24	0.45	0.09	-2.52	-0.11	0.21	0.03	-1.25
Subtotal - Private Benefits	0.17	5.61	8.90	19.51	0.08	2.42	3.87	8.59
External and Governmental Benefits								
Reduction in Petroleum Market Externality	0.03	0.34	0.57	1.51	0.01	0.15	0.25	0.67
Reduced Health Damages	0.04	0.42	0.69	1.93	0.02	0.16	0.27	0.77
Reduced Climate Damages								
SC-GHG at 2.5% DR	0.52	6.27	10.39	27.10	0.52	6.27	10.39	27.10
SC-GHG at 2% DR	0.88	10.65	17.65	45.96	0.88	10.65	17.65	45.96
SC-GHG at 1.5% DR	1.56	18.94	31.35	81.57	1.56	18.94	31.35	81.57
Total Social Benefits								
SC-GHG at 2.5% DR	0.77	12.64	20.56	50.05	0.63	8.99	14.78	37.13
SC-GHG at 2% DR	1.13	17.03	27.82	68.92	0.99	13.38	22.04	56.00
SC-GHG at 1.5% DR	1.80	25.31	41.52	104.52	1.67	21.66	35.74	91.60
Net Social Benefits								
SC-GHG at 2.5% DR	0.53	9.24	14.94	36.28	0.51	7.41	12.12	30.39
SC-GHG at 2% DR	0.89	13.62	22.20	55.15	0.87	11.80	19.37	49.26
SC-GHG at 1.5% DR	1.57	21.91	35.90	90.75	1.55	20.08	33.08	84.86

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C. Physical and Environmental Effects

1. Passenger Cars and Light Trucks

NHTSA estimates various physical and environmental effects associated with the standards. These include quantities of fuel and electricity consumed, GHGs and criteria pollutants reduced, and health and safety impacts. Table V–23 shows the cumulative impacts grouped by decade, including the on-road fleet sizes, VMT, fuel consumption, and CO_2 emissions, across alternatives. The size of the on-road fleet increases in later decades regardless of alternative, but the greatest on-road fleet size projection is seen in the reference baseline, with fleet sizes declining as the alternatives become increasingly more stringent. This is attributable to the reduction in sales caused by increased regulatory costs, which overtime decreases the existing vehicle stock, and therefore the size of the overall fleet.

VMT increases occur in the two later decades, with the highest miles occurring from 2041–2050. Fuel consumption (measured in gallons or gasoline gallon equivalents) declines across both decades and alternatives as the alternatives become more stringent, as do GHG emissions.

Table V-23: Cumulative Effects for All Alternatives by Calendar Year Cohort

	No-Action	PC2LT002	PC1LT3	PC2LT4	PC3LT5	PC6LT8
On-Road Fleet (Million Units) [942]						
2022 - 2030	2,404	2,404	2,404	2,404	2,404	2,405
2031 - 2040	2,614	2,613	2,612	2,610	2,609	2,603
2041 - 2050	2,668	2,666	2,664	2,660	2,655	2,644
Vehicle Miles Traveled (Billion Miles) [943]						
2022 - 2030	27,853	27,855	27,857	27,858	27,859	27,860
2031 - 2040	33,656	33,702	33,728	33,751	33,773	33,808
2041 - 2050	34,480	34,530	34,566	34,591	34,621	34,666
Fuel Consumption (Billion Gallons/GGE)						
2022 - 2030	1,108	1,107	1,106	1,105	1,105	1,105
2031 - 2040	1,023	998	986	975	964	945
2041 - 2050	710	682	664	650	636	606
CO_2 Emissions (mmT)						
2022 - 2030	12,159	12,143	12,137	12,132	12,129	12,126
2031 - 2040	10,736	10,425	10,295	10,158	10,029	9,795
2041 - 2050	6,733	6,401	6,192	6,028	5,860	5,503

From a calendar year perspective, NHTSA's analysis estimates total annual consumption of fuel by the entire on-road fleet from calendar year 2022 through calendar year 2050. On this basis, gasoline and electricity consumption by the U.S. light-duty fleet evolves as shown in Figure IV–5 and Figure IV–6, each of which shows projections for the No-Action Alternative (No-Action Alternative, *i.e.,* the reference baseline), Alternative PC2LT002, Alternative PC1LT3, Alternative PC2LT4, Alternative PC3LT5, and Alternative PC6LT8. Gasoline consumption decreases over time, with the largest decreases occurring in more stringent alternatives. Electricity consumption increases over time, with the same pattern of Alternative PC6LT8 experiencing the highest magnitude of change.

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[942] These rows report total vehicle units observed during the period. For example, 2,404 million units are modeled in the on-road fleet for calendar years 2022–2030. On average, this represents approximately 267 million vehicles in the on-road fleet for each calendar year in this calendar year cohort.

[943] These row report total miles traeled during the period. For example, 27,853 billion miles traveled in calendar years 2022-2030. On average, this represents approximately 3.05 trillion annual miles traveled in this calendar year cohort.

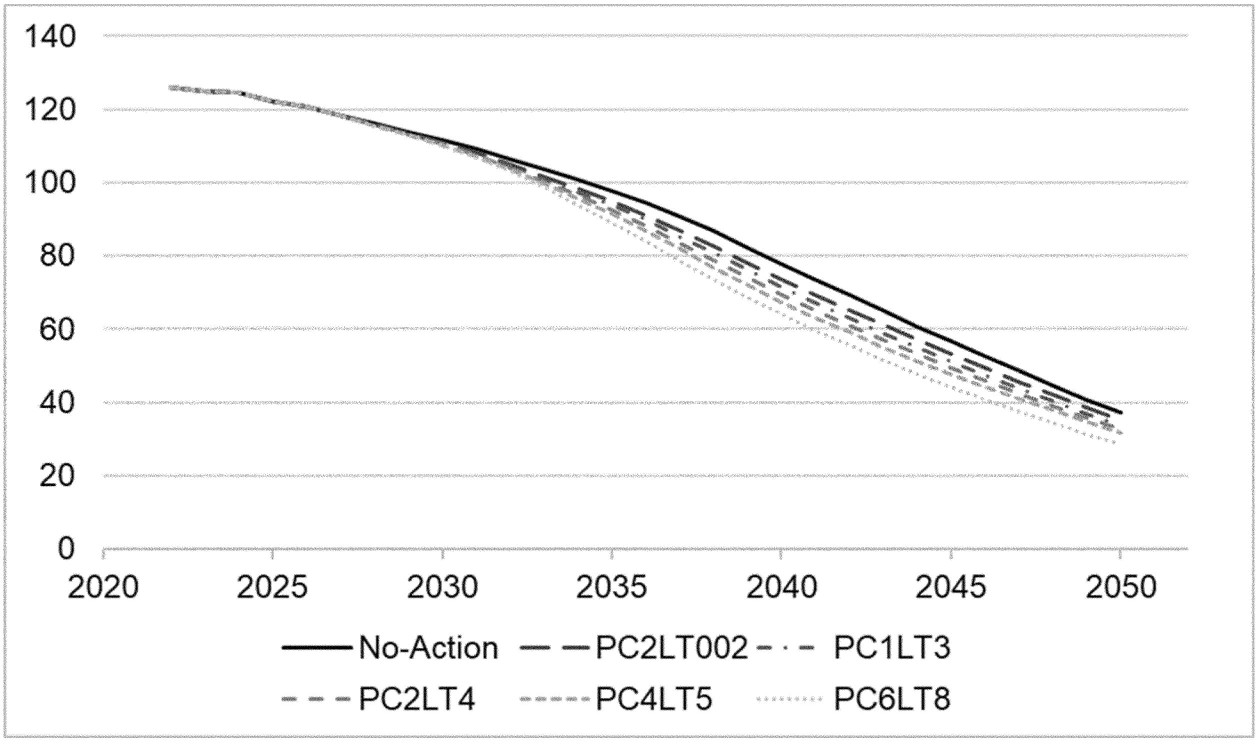

Figure V-5: Gasoline Consumption by Calendar Year and Alternative (Billions of Gallons)

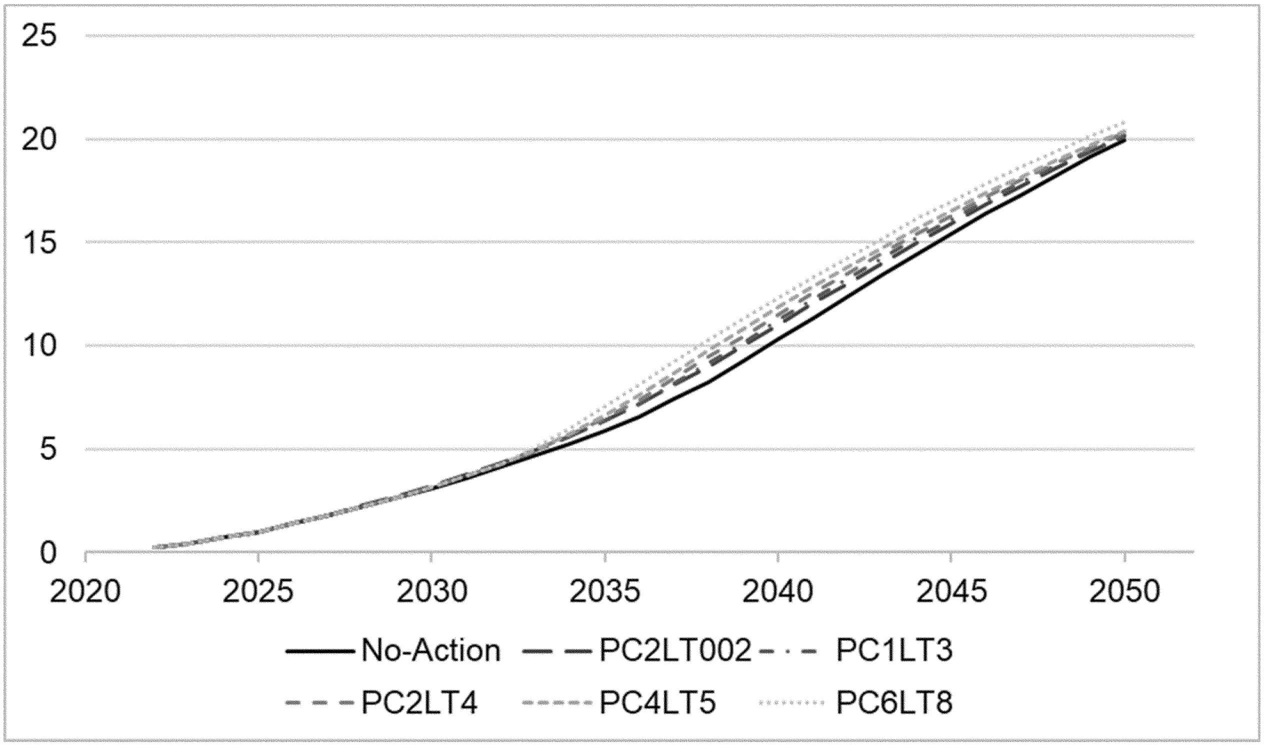

Figure V-6: Electricity Consumption by Calendar Year and Alternative (Billions of Gasoline Gallon Equivalents)

NHTSA estimates the GHGs attributable to the light-duty on-road fleet, from both vehicles and upstream energy sector processes (*e.g.,* petroleum refining, fuel transportation and distribution, electricity generation). Figure IV–7, Figure IV–8, and Figure IV–9 present NHTSA's estimate of how emissions from these three GHGs across all fuel types could evolve over the years. Note that these graphs include emissions from both downstream (powertrain and BTW) and upstream processes. All three GHG emissions follow similar trends of decline in the years between 2022–2050. Note that CO_2 emissions are expressed in units of million metric tons (mmt) while emissions from other pollutants are expressed in metric tons.

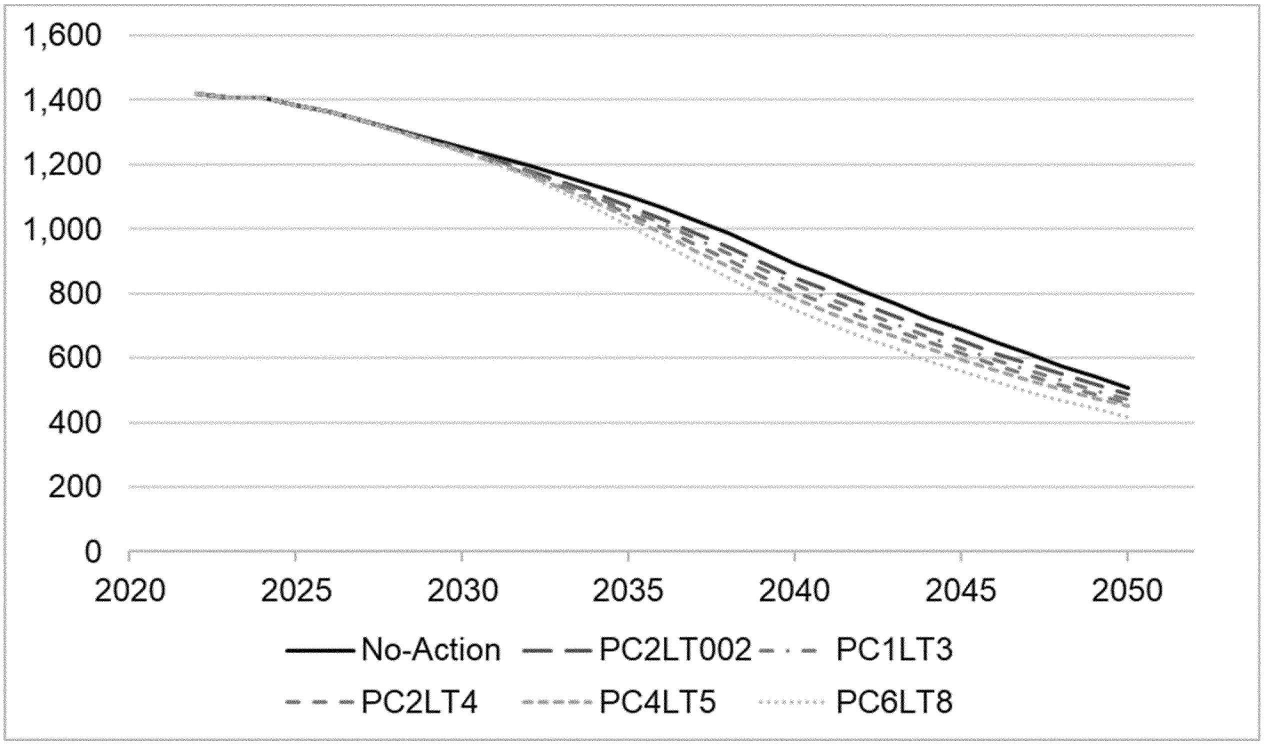

Figure V-7: Total CO2 Emissions by Calendar Year and Alternative (Million Metric Tons)

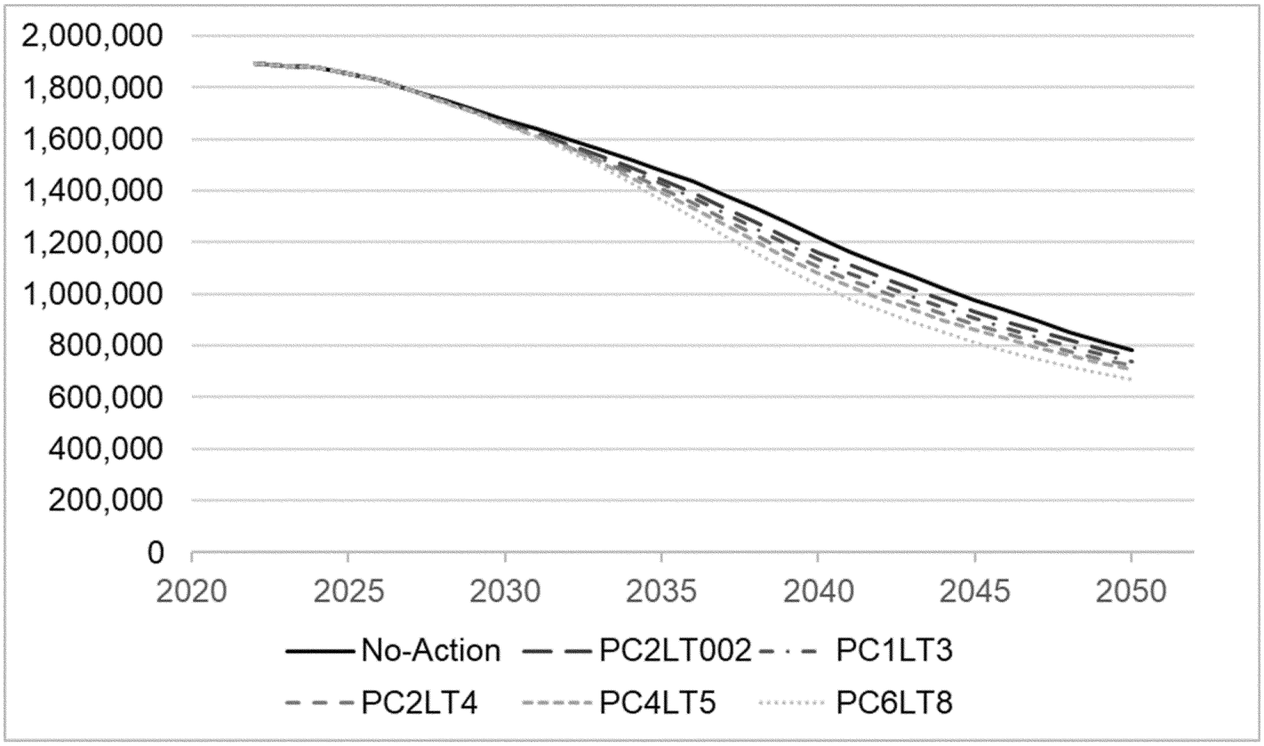

Figure V-8: Total CH4 Emissions by Calendar Year and Alternative (Tons)

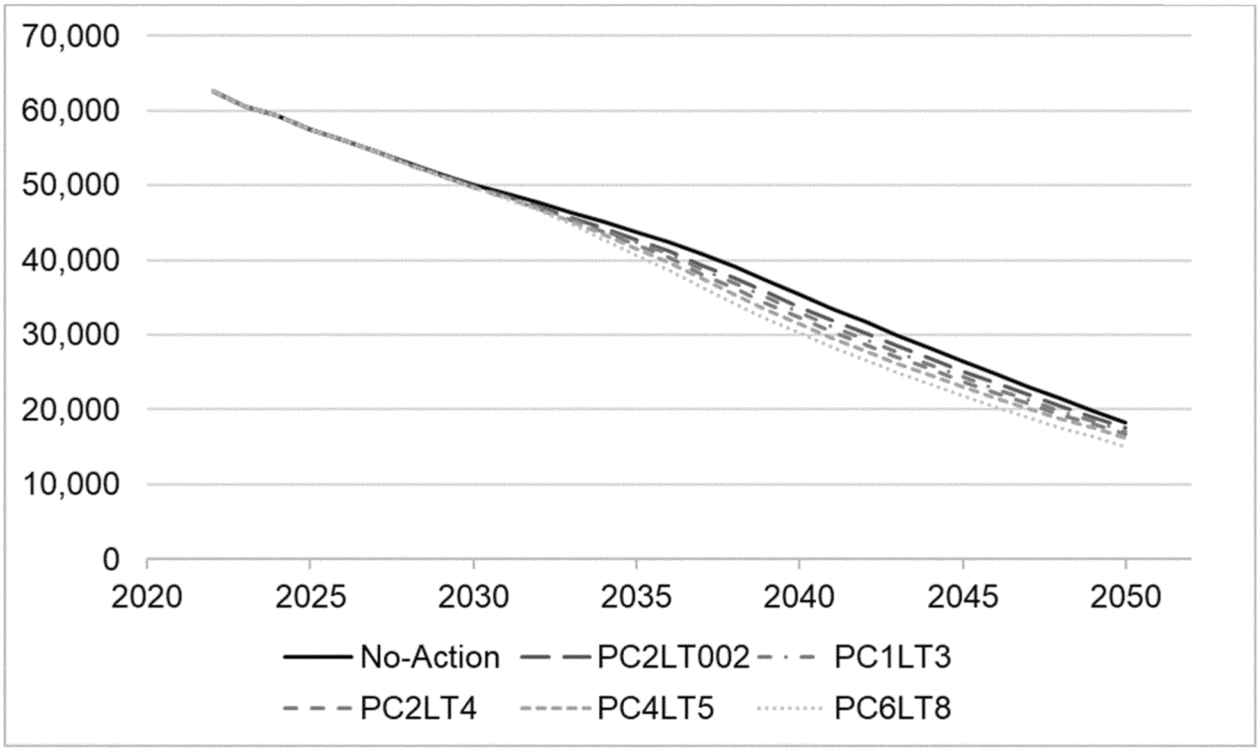

Figure V-9: Total N2O Emissions by Calendar Year and Alternative (Tons)

The figures presented here are not the only estimates NHTSA calculates regarding projected GHG emissions in future years. The accompanying EIS uses an ''unconstrained'' analysis as opposed to the ''standard setting'' analysis presented in this final rule. For more information regarding projected GHG emissions, as well as model-based estimates of corresponding impacts on several measures of global climate change, see the EIS.

NHTSA also estimates criteria pollutant emissions resulting from downstream (powertrain and BTW) and upstream processes attributable to the light-duty on-road fleet. Since the NPRM, NHTSA has adopted the NREL 2022 grid mix forecast which projects significant reductions in criteria emission rates from upstream electricity production. This results in further emission reductions across alternatives as EVs in the reference baseline induce marginally less emissions relative to the NPRM. This decrease in criteria pollutant emissions in turn leads to a decrease in adverse health outcomes described in later sections. Under each regulatory alternative, NHTSA projects a dramatic decline in annual emissions of NO_X, and $PM_{2.5}$ attributable to the light-duty on-road fleet between 2022 and 2050. As exemplified in Figure V–10, NOx emissions in any given year could be very nearly the same under each regulatory alternative.

On the other hand, as discussed in the FRIA Chapter 8.2 and Chapter 4 of the EIS accompanying this document, NHTSA projects that annual SO_2 emissions attributable to the LD on-road fleet could increase by 2050, after significant fluctuation, in all of the alternatives, including the reference baseline, due to greater use of electricity for PHEVs and BEVs (See Figure IV–6). Differences between the action alternatives are modest.

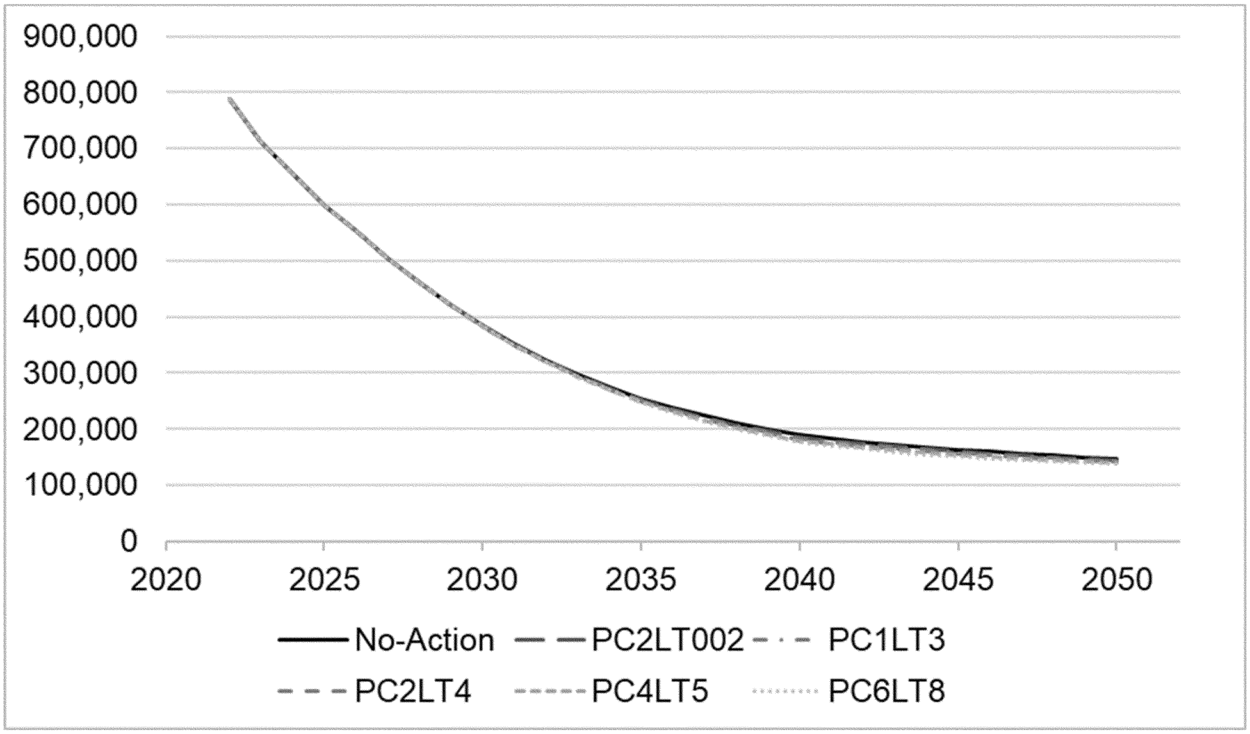

Figure V-10: Total NOx Emissions by Calendar Year and Alternative (Tons)

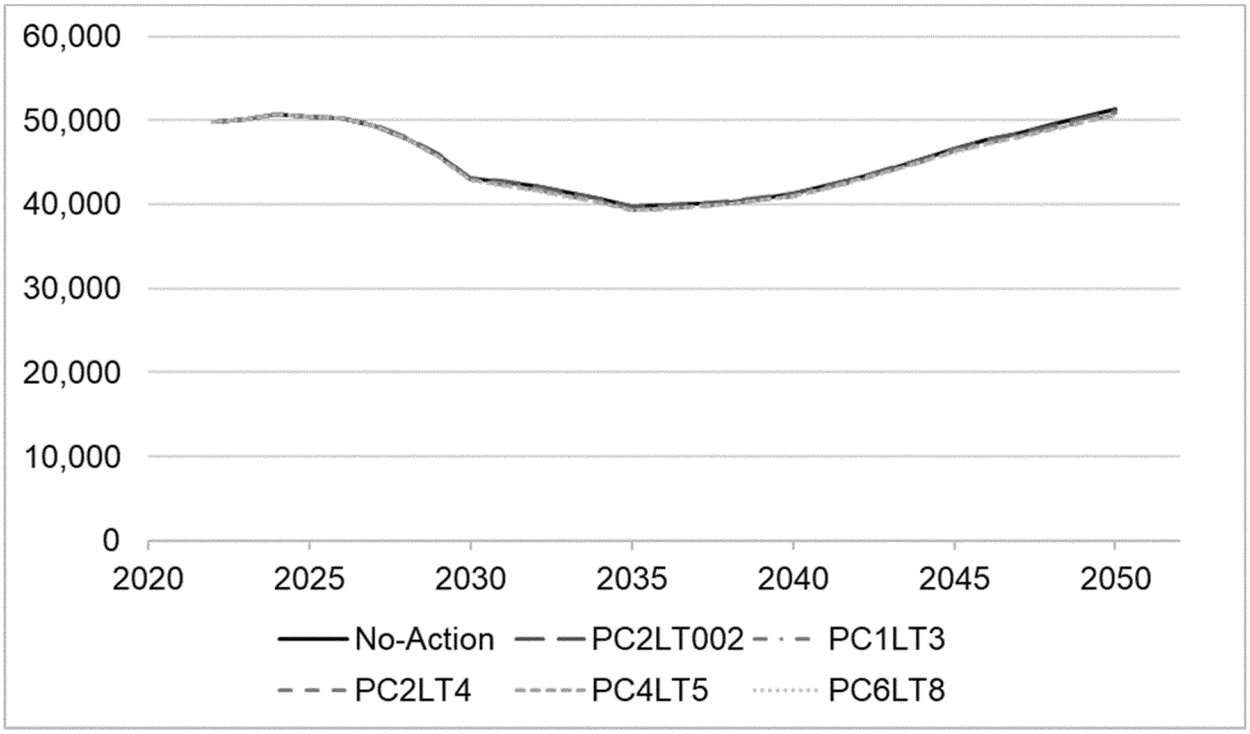

Figure V-11: Total SO2 Emissions by Calendar Year and Alternative (Tons)

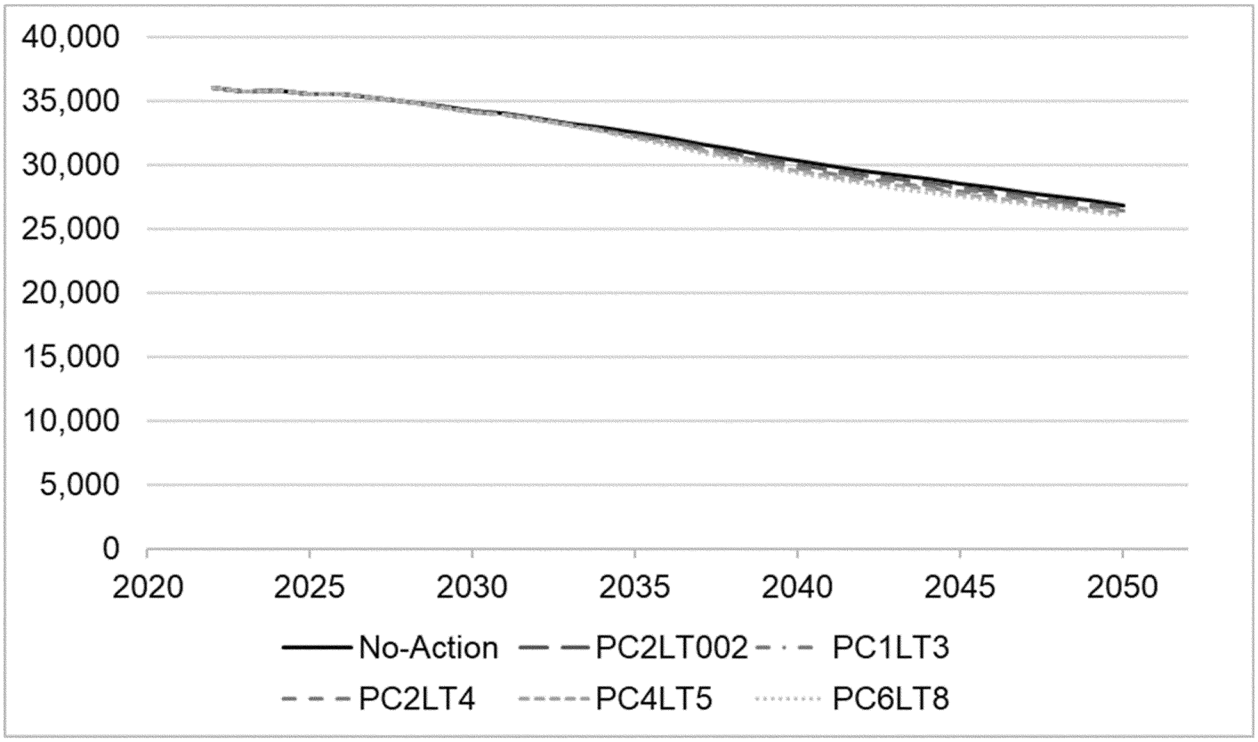

Figure V-12: Total PM2.5 Emissions by Calendar Year and Alternative (Tons)

Health impacts quantified by the CAFE Model include various instances of hospital visits due to respiratory problems, minor restricted activity days, non-fatal heart attacks, acute bronchitis, premature mortality, and other effects of criteria pollutant emissions on health. Table V–24 shows the split in select health impacts relative to the No-Action

Alternative, across all action alternatives. The magnitude of the differences relates directly to the changes in tons of criteria pollutants emitted. Magnitudes differ across health impact types because of variation in the reference baseline totals; for example, the total Minor Restricted Activity Days are much higher than the Respiratory Hospital Admissions. See Chapter 5.4 of the TSD for information regarding how the CAFE Model calculates these health impacts.

Table V-24: Emission Health Impacts Across Alternatives Relative to the No-Action Alternative (CY 2022-2050)

Measures (Incidents)	PC2LT002	PC1LT3	PC2LT4	PC3LT5	PC6LT8
Premature Deaths	-670	-959	-1,233	-1,574	-2,079
Respiratory Emergency Room Visits	-390	-555	-713	-910	-1,204
Acute Bronchitis	-1,012	-1,435	-1,844	-2,353	-3,113
Lower Respiratory Symptoms	-12,872	-18,257	-23,455	-29,936	-39,605
Upper Respiratory Symptoms	-18,296	-25,930	-33,311	-42,518	-56,255
Minor Restricted Activity Days	-550,125	-777,232	-998,073	-1,273,264	-1,686,039
Work Loss Days	-93,628	-132,334	-169,940	-216,788	-287,054
Asthma Exacerbation	-21,502	-30,471	-39,143	-49,967	-66,105
Cardiovascular Hospital Admissions	-178	-255	-328	-418	-553
Respiratory Hospital Admissions	-169	-241	-310	-396	-523
Non-Fatal Heart Attacks (Peters)	-697	-997	-1,282	-1,635	-2,160
Non-Fatal Heart Attacks (All Others)	-75	-107	-138	-176	-233

Lastly, NHTSA also quantifies safety impacts in its analysis. These include estimated counts of fatalities, non-fatal injuries, and property damage crashes occurring over the lifetimes of the LD on-road vehicles considered in the analysis. The following table shows the changes in these counts projected in action alternatives relative to the reference baseline.

Table V-25: Change in Safety Outcomes Across Alternatives Relative to the No-Action Alternative (CY 2022-2050)

Alternative	PC2LT002	PC1LT3	PC2LT4	PC3LT5	PC6LT8
Fatalities					
Fatalities from Mass Changes	0	-30	-40	-60	65
Fatalities from Rebound Effect	426	698	915	1,133	1,484
Fatalities from Sales/Scrappage	16	20	60	116	215
Total	442	688	935	1,189	1,764
Non-Fatal Crashes					
Non-Fatal Crash from Mass Changes	-17	-4,721	-6,437	-9,560	10,517
Non-Fatal Crash from Rebound Effect	67,888	111,123	145,705	180,463	236,560
Non-Fatal Crash from Sales/Scrappage	998	291	3,668	8,781	15,943
Total	68,869	106,692	142,935	179,683	263,020
Property Damaged Vehicles					
Property Damage Vehicles from Mass Changes	770	-15,964	-21,594	-32,168	38,593
Property Damage Vehicles from Rebound Effect	226,067	371,536	486,205	602,874	792,940
Property Damage Vehicles from Sales/Scrappage	-8,313	-20,236	-36,412	-55,721	-93,846
Total	218,524	335,336	428,200	514,985	737,686

Generally, increasing fuel economy stringency leads to more adverse safety outcomes from increased rebound VMT (motorists choosing to drive more as driving becomes cheaper), and the reduction in scrappage causing older vehicles with less safety features to remain in the fleet longer. The impacts of mass reduction are nonlinear and depend on the specific fleet receiving those reductions, with mass reduction to PCs generally causing an increase in adverse safety outcomes and mass reductions for LTs generally causing a decrease in adverse safety outcomes; this explains the difference in the impacts of mass reduction for Alternative PC6LT8, as this alternative sees the largest transition from LTs to PCs and has PCs receiving the most mass reductions. NHTSA notes that none of these safety outcomes due to mass reduction can be statistically distinguished from zero. Chapter 7.1.5 of the FRIA accompanying this document contains an in-depth discussion on the effects of the various alternatives on these safety measures, and Chapter 7 of the TSD contains information regarding the construction of the safety estimates.

We also analyze physical and environmental effects relative to the No ZEV alternative baseline. In the model year perspective (model years through 2031), in the preferred alternative (PC2LT002) relative to the No ZEV alternative baseline, CO_2 emission reductions are 1,207 MMT, compared to the reduction in CO_2 emissions in the preferred alternative relative to the reference baseline (659 MMT).

2. Heavy-Duty Pickups and Vans

NHTSA estimates the same physical and environmental effects for HDPUVs as it does for LDVs, including: quantities of fuel and electricity consumption; tons of GHG emissions and criteria pollutants reduced; and health and safety impacts. Table V–26 shows the cumulative impacts grouped by decade, including the on-road fleet sizes, VMT, fuel consumption, and CO_2 emissions, across alternatives. The size of the on-road fleet increases in later decades regardless of the alternative, but the greatest on-road fleet size projection is seen in the reference baseline. Most differences between the alternatives are not visible in the Table V–26 due to rounding.

VMT increases occur in the later two decades, with the highest numbers occurring from 2041–2050. Across alternatives, the VMT increases remain around approximately the same magnitude. Fuel consumption (measured in gallons or gasoline gallon equivalents) declines across decades, as do GHG emissions. Differences between the alternatives are minor but fuel consumption and GHG emissions also decrease as alternatives become more stringent. As discussed in the previous section, since the agency does not constrain VMT for HDPUVs, alternatives with fewer vehicles see a corresponding decrease in VMT.[944] [945]

Table V-26: Cumulative Impacts for All Alternatives by Calendar Year Cohort

	No-Action	HDPUV4	HDPUV 108	HDPUV10	HDPUV14
On-Road Fleet (Million Units) [944]					
2022 – 2030	152	152	152	152	152
2031 – 2040	184	184	184	184	184
2041 – 2050	208	208	207	207	207
Vehicle Miles Traveled (Billion Miles) [945]					
2022 – 2030	1,992	1,992	1,992	1,992	1,992
2031 – 2040	2,584	2,584	2,583	2,583	2,583
2041 – 2050	2,917	2,917	2,916	2,916	2,914
Fuel Consumption (Billion Gallons/GGE)					
2022 – 2030	143	143	143	143	143
2031 – 2040	145	145	144	143	140
2041 – 2050	131	131	128	126	119
CO_2 Emissions (mmT)					
2022 – 2030	1,617	1,617	1,617	1,617	1,617
2031 – 2040	1,540	1,538	1,528	1,516	1,466
2041 – 2050	1,302	1,299	1,260	1,235	1,140

Figure V–13 and Figure V–14 show the estimates of gasoline and electricity consumption of the on-road HDPUV fleet for all fuel types over time on a calendar year basis, from 2022–2050. The four action alternatives, HDPUV4, HDPUV108, HDPUV10, and HDPUV14, are compared to the reference baseline changes over time.

Gasoline consumption decreases over time, with the largest decreases occurring in more stringent alternatives. Electricity consumption increases over time, with the same pattern of Alternative HDPUV14 experiencing the highest magnitude of change. In both charts, the differences in magnitudes across alternatives do not vary drastically.

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[944] These rows report total vehicle units observed during the period. For example, 152 million units are modeled in the on-road fleet for calendar years 2022–2030. On average, this represents approximately 17 million vehicles in the on-road fleet for each calendar year in this calendar year cohort.

[945] These rows report total miles traveled during the period. For example, 1.992 trillion miles traveled in calendar years 2022–2030. On average, this represents approximately 221 billion annual miles traveled in this calendar year cohort.

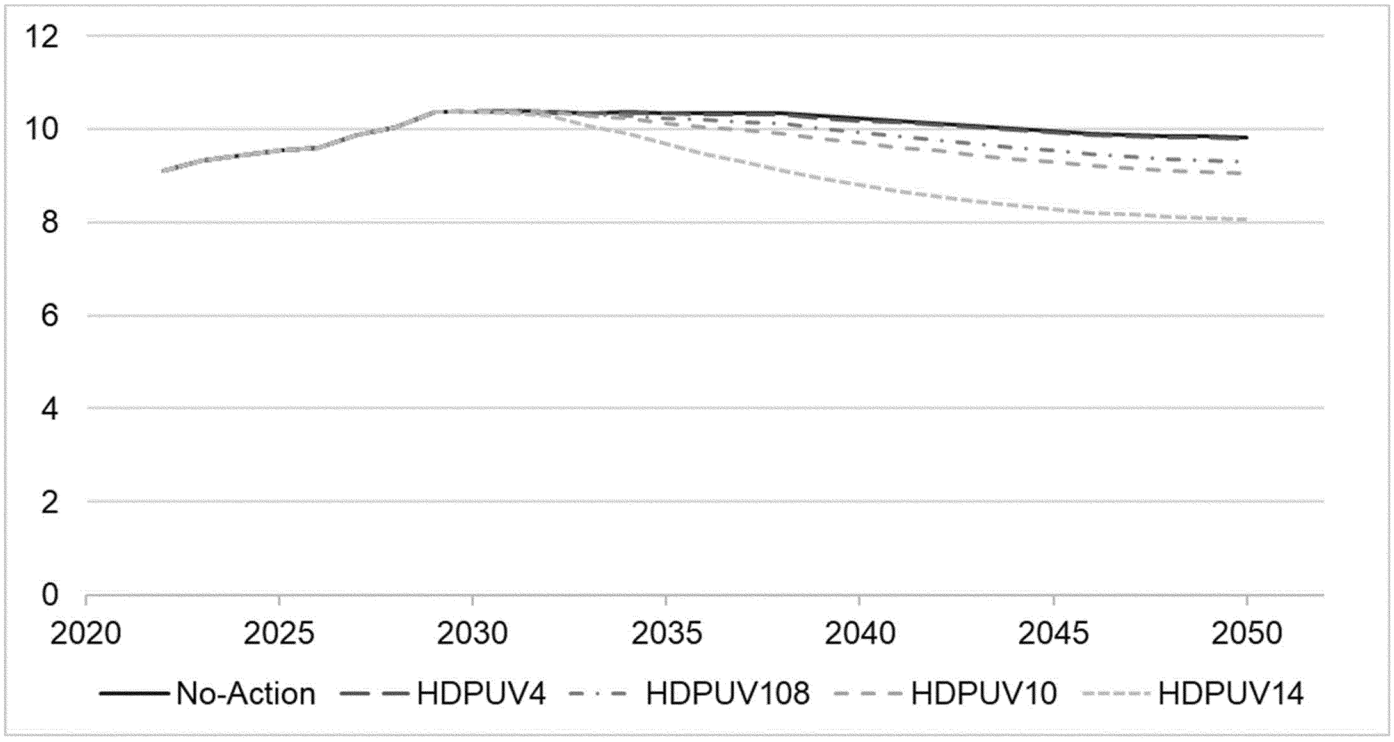

Figure V-13: Total Gasoline Consumption by Calendar Year and Alternative (Billions of Gallons)

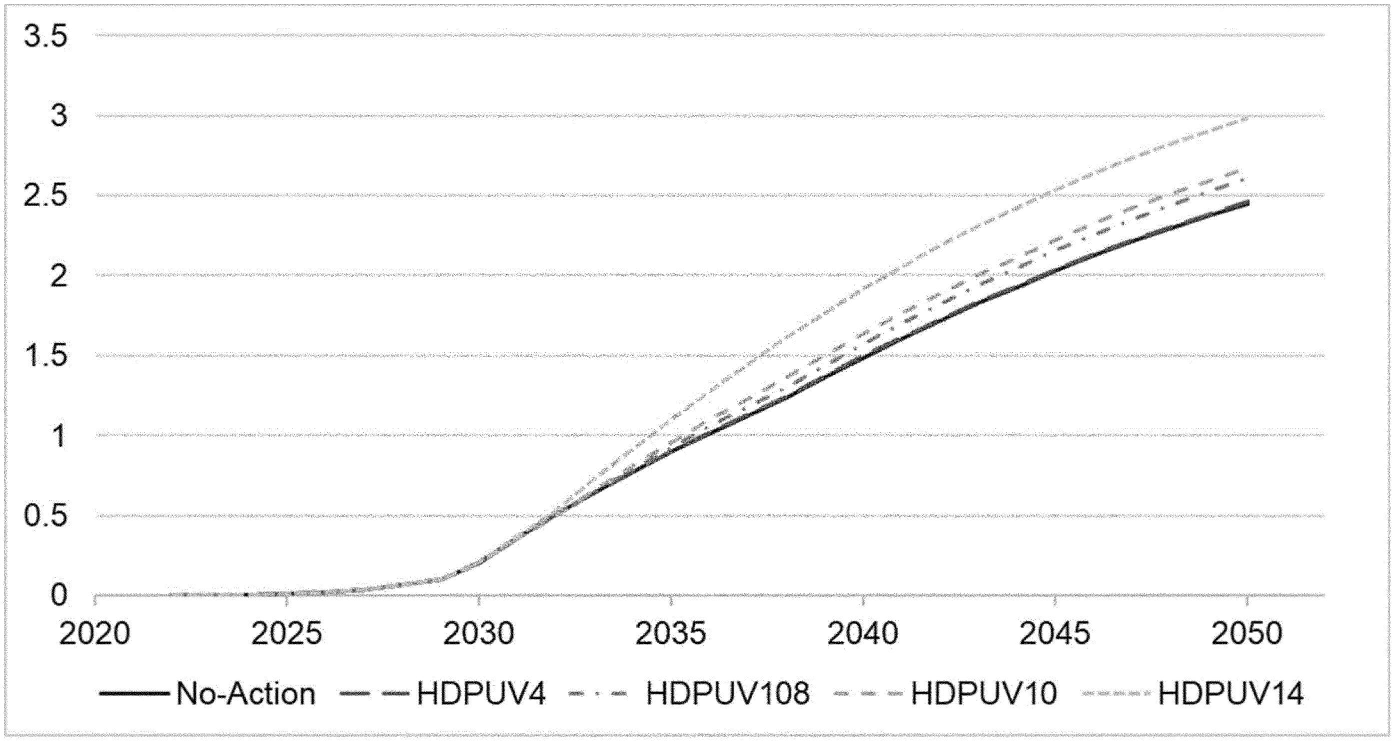

Figure V-14: Total Electricity Consumption by Calendar Year and Alternative (Billions of Gasoline Gallon Equivalents)

NHTSA estimates the GHGs attributable to the HDPUV on-road fleet, from both downstream and upstream energy sector processes (*e.g.,* petroleum refining, fuel transportation and distribution, electricity generation). These estimates mirror those discussed in the light-duty section above. Figure IV15, Figure IV16, and Figure IV17 present NHTSA's estimate of how emissions from these three GHGs could evolve over the years (CY 2022–2050). Emissions from all three GHG types tracked follow similar trends of decline in the years between 2022–2050. Note that these graphs include emissions from both vehicle and upstream processes and scales vary by figure (CO_2 emissions are expressed in units of million metric tons (mmt) while emissions from other pollutants are expressed in metric tons). NHTSA's calculation of N_2O emissions has changed since the NPRM resulting in increased emission rates for diesel vehicles, which comprise a significant portion of the HDPUV fleet.

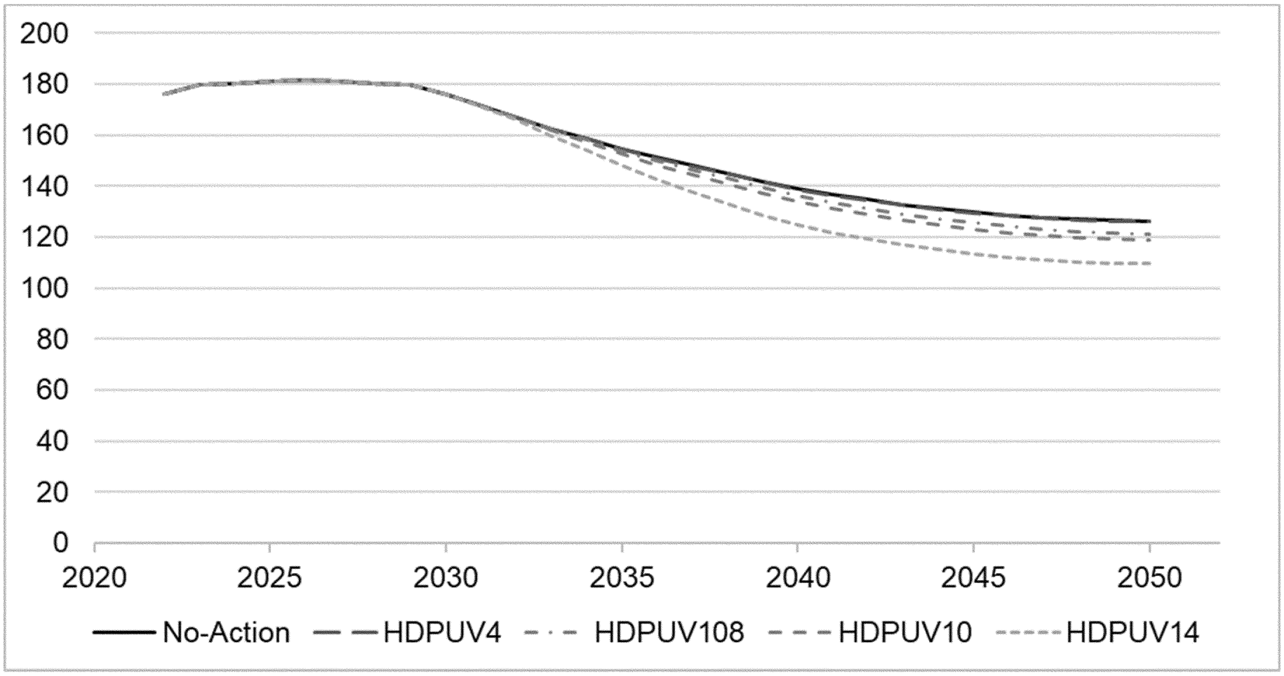

Figure V-15: Total CO2 Emissions by Calendar Year and Alternative (Millions of Metric Tons)

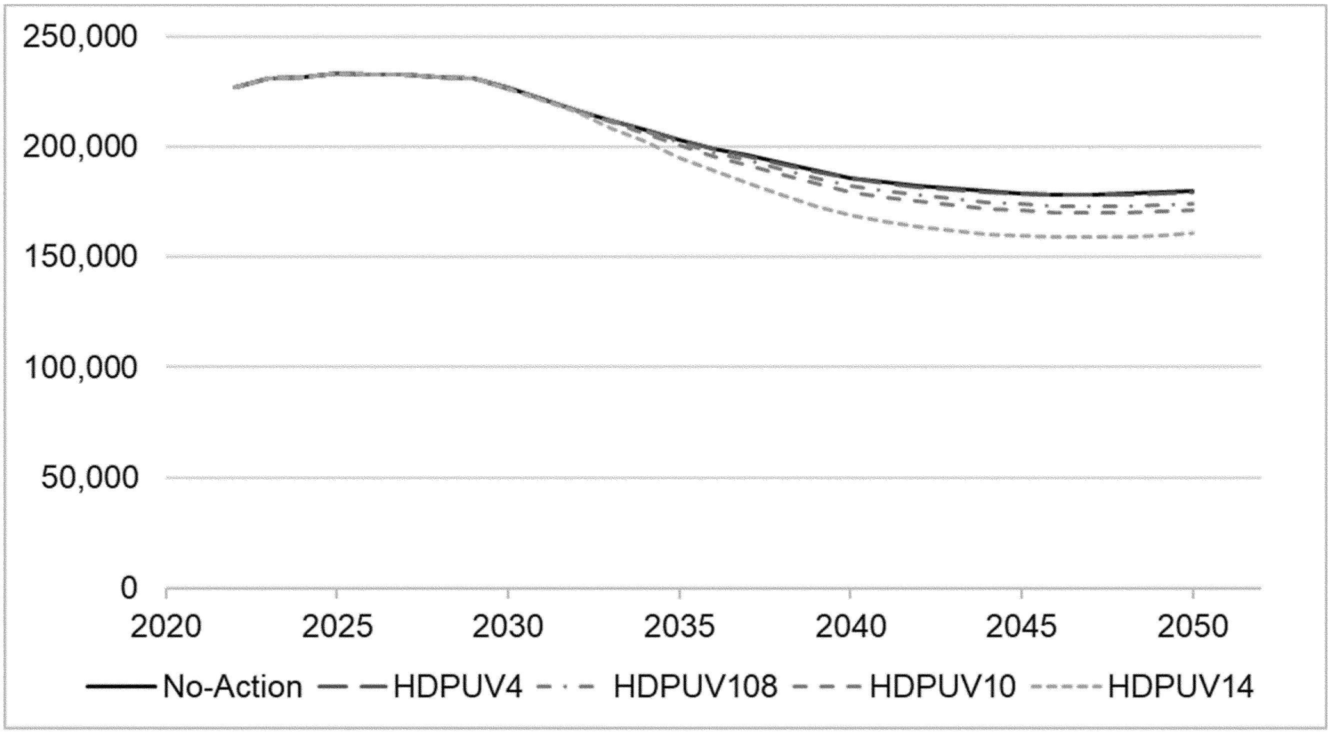

Figure V-16: Total CH4 Emissions by Calendar Year and Alternative (Tons)

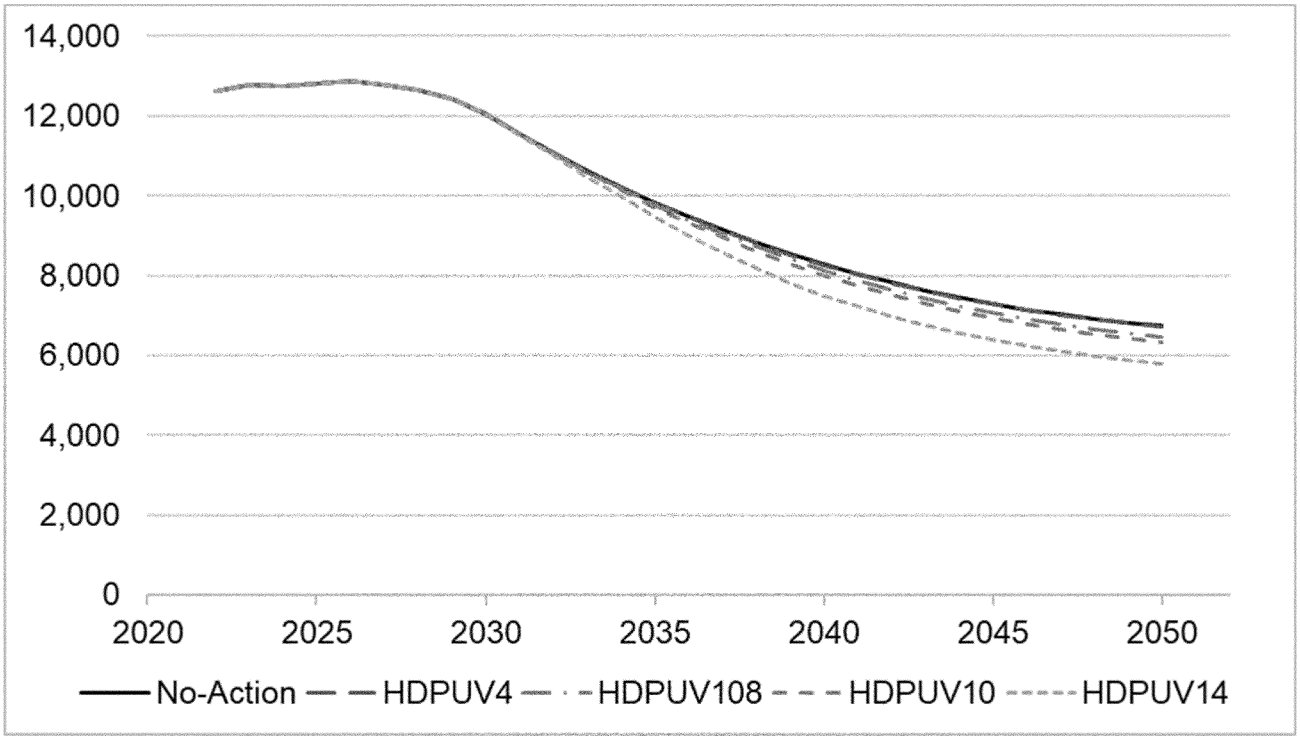

Figure V-17: Total N2O Emissions by Calendar Year and Alternative (Tons)

For more information regarding projected GHG emissions, as well as model-based estimates of corresponding impacts on several measures of global climate change, see the EIS.

NHTSA also estimates criteria pollutant emissions resulting from vehicle and upstream processes attributable to the HDPUV on-road fleet. Under each regulatory alternative, NHTSA projects a significant decline in annual emissions of NO_X, and $PM_{2.5}$ attributable to the HDPUV on-road fleet between 2022 and 2050. As exemplified in Figure IV–18, the magnitude of emissions in any given year could be very similar under each regulatory alternative.

On the other hand, as discussed in the FRIA Chapter 8.3 and the EIS, NHTSA projects that annual SO_2 emissions attributable to the HDPUV on-road fleet could increase modestly under the action alternatives, because, as discussed above, NHTSA projects that each of the action alternatives could lead to greater use of electricity (for PHEVs and BEVs) in later calendar years.

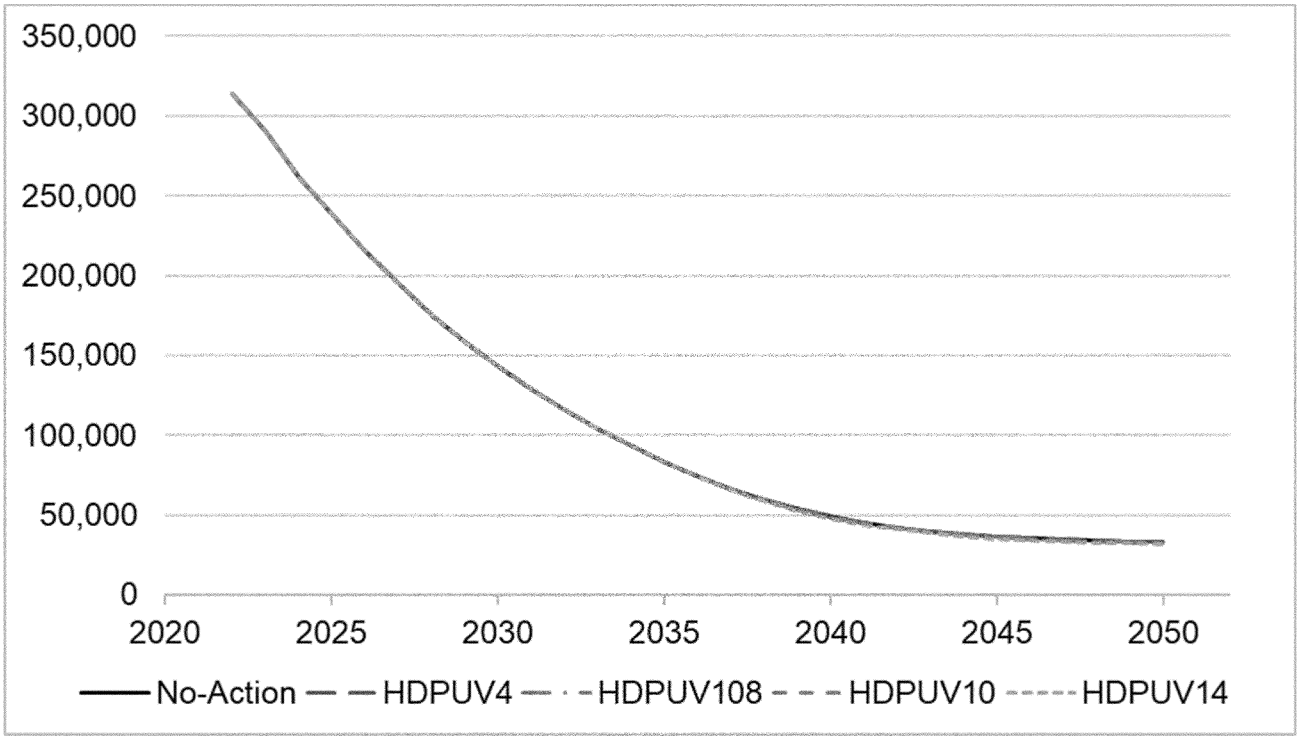

Figure V-18: Total NOx Emissions by Calendar Year and Alternative (Tons)

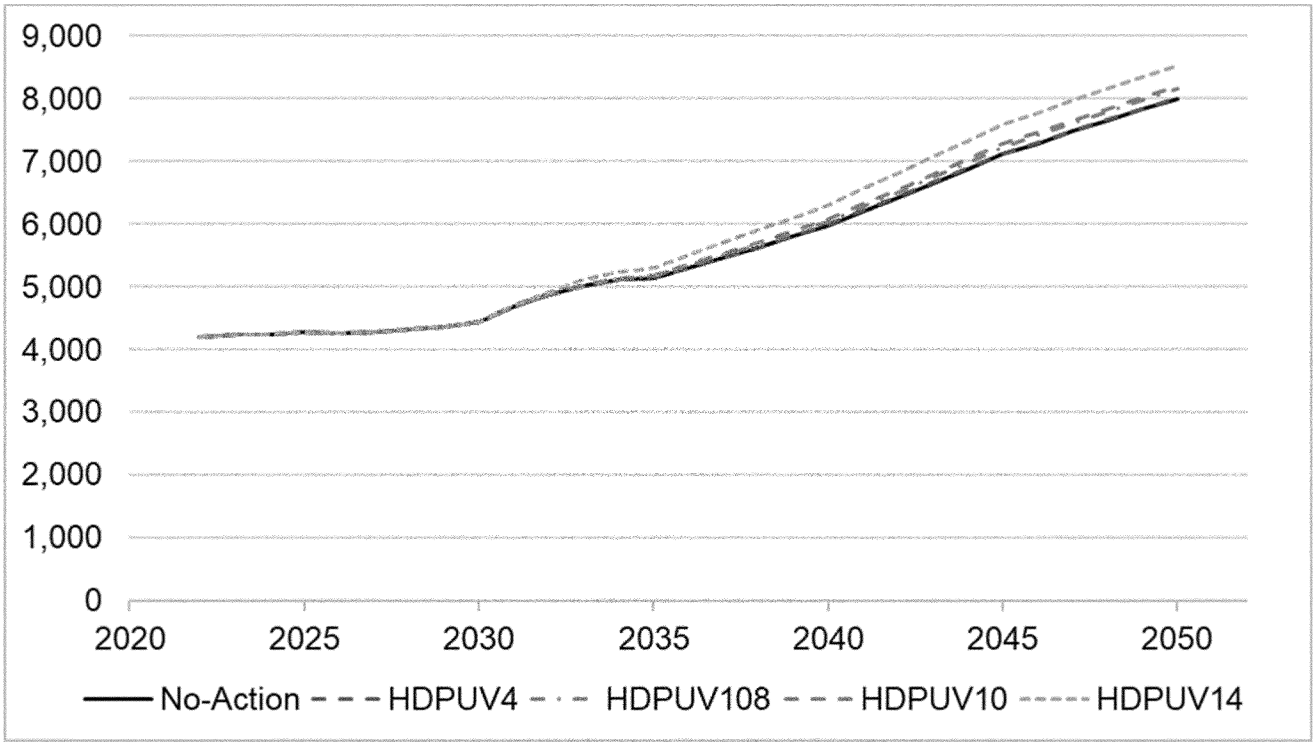

Figure V-19: Total SO2 Emissions by Calendar Year and Alternative (Tons)

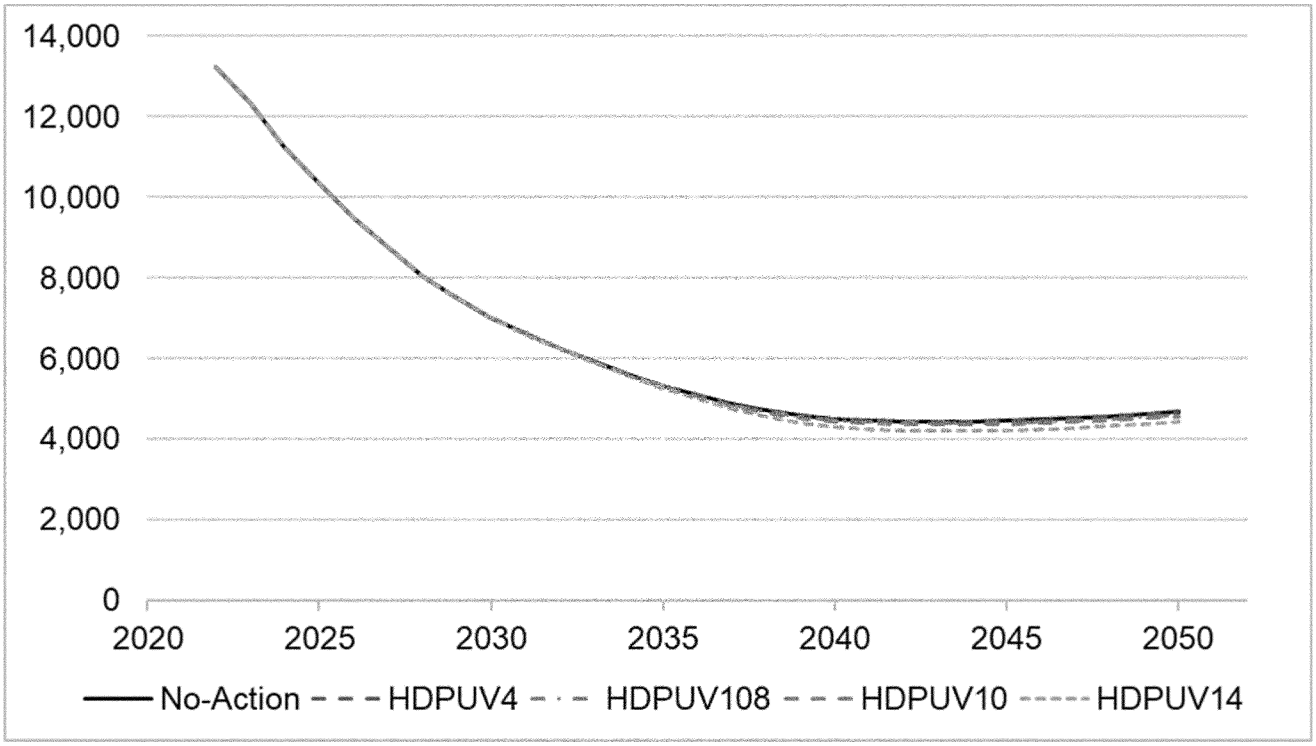

Figure V-20: Total PM2.5 Emissions by Calendar Year and Alternative (Tons)

Health impacts quantified by the CAFE Model include various instances of hospital visits due to respiratory problems, minor restricted activity days, non-fatal heart attacks, acute bronchitis, premature mortality, and other effects of criteria pollutant emissions on health. Table V–27 shows select health impacts relative to the baseline, across all action alternatives. The magnitude of the differences relates directly to the changes in tons of criteria pollutants emitted. The magnitudes differ across health impact types because of variation in the totals; for example, the total Minor Restricted Activity Days are much higher than the Respiratory Hospital Admissions. See Chapter 5.4 of the TSD for information regarding how the CAFE Model calculates these health impacts.

Table V-27: Emission Health Impacts Across Alternatives Relative to the No-Action Alternative (CY 2022-2050)

Measures (Incidents)	HDPUV4	HDPUV108	HDPUV10	HDPUV14
Premature Deaths	-8	-81	-132	-362
Respiratory Emergency Room Visits	-4	-48	-78	-213
Acute Bronchitis	-12	-124	-202	-554
Lower Respiratory Symptoms	-149	-1,572	-2,566	-7,037
Upper Respiratory Symptoms	-213	-2,238	-3,653	-10,018
Minor Restricted Activity Days	-6,572	-69,201	-112,840	-309,753
Work Loss Days	-1,092	-11,520	-18,796	-51,550
Asthma Exacerbation	-250	-2,633	-4,296	-11,783
Cardiovascular Hospital Admissions	-2	-21	-35	-96
Respiratory Hospital Admissions	-2	-20	-33	-91
Non-Fatal Heart Attacks (Peters)	-8	-84	-137	-376
Non-Fatal Heart Attacks (All Others)	-1	-9	-15	-40

Lastly, NHTSA also quantifies safety impacts in its analysis. These include estimated counts of fatalities, non-fatal injuries, and property damage crashes occurring over the lifetimes of the HD on-road vehicles considered in the analysis. The following table shows projections of these counts in action alternatives relative to the baseline. As noted earlier, the safety impacts for HDPUV are a result of changes in aggregate VMT.

Table V-28: Change in Safety Outcomes Across Alternatives Relative to the No-Action Alternative (CY 2022-2050)

Alternative	HDPUV4	HDPUV108	HDPUV10	HDPUV14
Fatalities				
Fatalities from Mass Changes	0	0	0	0
Fatalities from Rebound Effect	0	5	10	20
Fatalities from Sales/Scrappage	0	-12	-18	-40
Total	0	-6	-8	-20
Non-Fatal Crashes				
Non-Fatal Crash from Mass Changes	0	0	0	0
Non-Fatal Crash from Rebound Effect	43	880	1,672	3,228
Non-Fatal Crash from Sales/Scrappage	-38	-1,873	-2,936	-6,538
Total	5	-993	-1,264	-3,310
Property Damaged Vehicles				
Property Damage Vehicles from Mass Changes	0	0	0	0
Property Damage Vehicles from Rebound Effect	145	3,140	5,918	11,270
Property Damage Vehicles from Sales/Scrappage	-129	-6,805	-10,608	-23,211
Total	16	-3,665	-4,690	-11,941

Chapter 7.1.5 of the FRIA accompanying this document contains an in-depth discussion on the effects of the various alternatives on these safety measures, and TSD Chapter 7 contains information regarding the construction of the safety estimates.

D. Sensitivity Analysis, Including Alternative Baseline

The analysis conducted to support this rulemaking consists of data, estimates, and assumptions, all applied within an analytical framework, the CAFE Model. Just as with all past CAFE and HDPUV rulemakings, NHTSA recognizes that many analytical inputs are uncertain, and some inputs are very uncertain. Of those uncertain inputs, some are likely to exert considerable influence over specific types of estimated impacts, and some are likely to do so for the bulk of the analysis. Yet making assumptions in the face of that uncertainty is necessary when analyzing possible future events (*e.g.,* consumer and industry responses to fuel economy/efficiency regulation). In other cases, we made assumptions in how we modeled the effects of other existing regulations that affected the costs and benefits of the action alternatives (*e.g.,* state ZEV programs were included in the No-Action Alternative). To better understand the effect that these assumptions have on the analytical findings, we conducted additional model runs with alternative assumptions. These additional runs were specified in an effort to explore a range of potential inputs and the sensitivity of estimated impacts to changes in these model inputs. Sensitivity cases and the alternative baseline in this analysis span assumptions related to technology applicability and cost, economic conditions, consumer preferences, externality values, and safety assumptions, among others.[946] A sensitivity analysis can identify two critical pieces of information: *how big of an influence* does each parameter exert on the analysis, and *how sensitive are the model results* to that assumption?

That said, influence is different from likelihood. NHTSA does not mean to suggest that any one of the sensitivity cases presented here is inherently more likely than the collection of assumptions that represent the reference baseline in the figures and tables that follow. Nor is this sensitivity analysis intended to suggest that only one of the many assumptions made is likely to prove off-base with the passage of time or new observations. It is more likely that, when assumptions are eventually contradicted by future observation (*e.g.,* deviations in observed and predicted fuel prices are nearly a given), there will be *collections* of assumptions, rather than individual parameters, that simultaneously require updating. For this reason, we do not interpret the sensitivity analysis as necessarily providing justification for alternative regulatory scenarios to be preferred. Rather, the analysis simply provides an indication of which assumptions are most critical, and the extent to which future deviations from central analysis assumptions could affect costs and benefits of the rule. For a full discussion of how this information relates to NHTSA's determination of which regulatory alternatives are maximum feasible, please see Section VI.D].

Table V–29 lists and briefly describes the cases and alternative baseline that we examined in the sensitivity analysis. Note that some cases only apply to the LD fleet (*e.g.,* scenarios altering assumptions about fleet share modeling) and others only affect the HDPUV analysis (*e.g.,* initial PHEV availability).

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[946] In contrast to an uncertainty analysis, where many assumptions are varied simultaneously, the sensitivity analyses included here vary a single assumption and provide information about the influence of each individual factor, rather than suggesting that an alternative assumption would have justified a different Preferred Alternative.

Table V-29: Cases and Alternative Baseline Included in the Sensitivity Analysis

Case Name	Description
Reference baseline	Reference baseline
No ZEV alternative baseline (LD)	No BEVs added in response to ACC I or in response to expected manufacturer deployment at levels consistent with ACC II
EIS	Reference baseline for Environmental Impact Statement (EIS)
NPRM battery learning curve	Battery learning curve used for the NPRM.
Battery DMC (+25%)	Battery direct manufacturing cost (DMC) increased by 25 percent
Battery DMC (-15%)	Battery direct manufacturing cost (DMC) decreased by 15 percent
Battery CAM cost (high)	Highest projected battery cathode active material (CAM) costs (opposed to average projected CAM costs, used in the reference baseline)
Battery CAM cost (low)	Lowest projected battery cathode active material (CAM) costs (opposed to average projected CAM costs, used in the reference baseline)
Annual vehicle redesigns	Vehicles redesigned every model year
Limited HCR skips	Removes all HCR skips
AC/OC NPRM Cap Error No-Action Mod	NPRM run with incorrect OC cap of 15 g/mi instead of 10 g/mi in 2027, all AC for BEVs, and reduced OC for BEVs starts in 2023 and includes No-Action alternative
AC/OC NPRM Cap No-Action Mod	NPRM run with correct OC cap of 10 g/mi instead of 15 g/mi in 2027, all AC for BEVs, and reduced OC for BEVs starts in 2023 and includes No-Action alternative
AC/OC Mod	AC/OC identical to reference baseline except reduced OC for BEVs starts in 2023 and includes No-Action alternative
PHEV available MY 2030	Shifts initial HDPUV PHEV availability to MY 2030
Oil price (high)	Fuel prices from AEO 2023 High Oil Price case
Oil price (low)	Fuel prices from AEO 2023 Low Oil Price case
GDP (high)	GDP and sales based on AEO 2023 high economic growth case
GDP (low)	GDP and sales based on AEO 2023 low economic growth case
GDP + fuel (high)	GDP, fuel prices, and sales from AEO 2023 high economic growth case

Case Name	Description
GDP + fuel (low)	GDP, fuel prices, and sales from AEO 2023 low economic growth case
Oil market externalities (low)	Price shock component set to 10th percentile of estimates.
Oil market externalities (high)	Price shock component set to 90th percentile of estimates.
Fuel reduction import share (50%)	Assume 50 percent share of fuel consumption reduction supplied by imports
Fuel reduction import share (100%)	Assume 100 percent share of fuel consumption reduction supplied by imports
No payback period	Payback period set to 0 months
24-month payback period	Payback period set to 24 months
30-month/70k miles payback	Valuation of fuel savings at 30 months for technology application, 70,000 miles for sales and scrappage models
36-month payback period	Payback period set to 36 months
60-month payback period	Payback period set to 60 months
120-month payback period	Payback period set to 120 months
Implicit opportunity cost	Includes a measure that estimates possible opportunity cost of forgone vehicle attribute improvements.
Rebound (5%)	Rebound effect set at 5 percent
Rebound (15%)	Rebound effect set at 15 percent
Sales-scrappage response (-0.1)	Sales-scrappage model with price elasticity multiplier of -0.1
Sales-scrappage response (-0.5)	Sales-scrappage model with price elasticity multiplier of -0.5
Sales-scrappage response (-1)	Sales-scrappage model with price elasticity multiplier of -1
LD sales (2022 FR)	LD sales model coefficients equal to those used in the 2022 CAFE Final Rule
LD sales (AEO 2023 levels)	LD sales levels consistent with AEO 2023 Reference case
LD sales (AEO 2023 growth)	LD sales rate of change consistent with AEO 2023 Reference case
No fleet share price response	Fleet share elasticity estimate set to 0 (i.e., no fleet share response across alternatives)
Fixed fleet share	Fleet share level fixed at 2023 value
Fixed fleet share, no price response	Fixed fleet share at 2023 level, fleet share elasticity set to zero
HDPUV sales (AEO reference)	HDPUV sales based on AEO 2023 Reference Case (i.e., no initial sales ramp)

Case Name	Description
HDPUV sales (AEO low economic growth)	HDPUV sales based on AEO 2023 Low Economic Growth Case without initial sales ramp
HDPUV sales (AEO high economic growth)	HDPUV sales based on AEO 2023 High Economic Growth Case with initial sales ramp
Commercial operator sales share (100%)	Assume all HDPUV vehicles are purchased by commercial operators. Applies commercial operator private net benefit offset.
Commercial operator sales share (50%)	Assume half of all HDPUV vehicles are purchased by commercial operators. Applies commercial operator private net benefit offset.
Mass-size-safety (low)	The lower bound of the 95 percent confidence interval for all mass-size-safety model coefficients.
Mass-size-safety (high)	The upper bound of the 95 percent confidence interval for all mass-size-safety model coefficients.
Crash avoidance (low)	Lower-bound estimate of effectiveness of six current crash avoidance technologies at avoiding fatalities, injuries, and property damage
Crash avoidance (high)	Upper-bound estimate of effectiveness of six current crash avoidance technologies at avoiding fatalities, injuries, and property damage
2022 FR fatality rates	Fatality rates at 2022 CAFE Final Rule levels
AEO 2023 grid forecast	Upstream emissions factors based on AEO 2023 (GREET 2023 default)
EPA Post-IRA grid forecast	Upstream emission factors based on EPA's IPM Post-IRA 2022 reference case
MOVES3 downstream emissions	Downstream emissions factors from MOVES3
IWG SC-GHG	SC-GHG values at IWG levels
Standard-setting conditions for MY 2027-2035	Applies standard-setting conditions for MY 2027-2035
Standard-setting conditions for MY 2027-2050	Applies standard-setting conditions for MY 2027-2050
Standard-setting conditions for MY 2023-2050	Applies standard-setting conditions for MY 2023-2050
Reduced ZEV compliance	Reduced ZEV percentage requirements prior to MY 2026 to model reduced ACC I compliance
PEF (NPRM)	NOPR PEF value used for CAFE NPRM (23,160 Wh/gal)

Case Name	Description
PEF (2022 FR)	PEF value used in prior CAFE rulemakings (82,049 Wh/gal)
Social discount rate at 2%	Social costs and benefits discounted using 2% discount rate
No EV tax credits	All IRA EV tax credits removed
No AMPC	IRA Advanced Manufacturing Production tax credit (AMPC) removed
Consumer tax credit share 75%	Consumer tax credit share set to 75 percent (25 percent captured by manufacturers)
Consumer tax credit share 25%	Consumer tax credit share set to 25 percent (75 percent captured by manufacturers)
Linear CVC values	Clean vehicle credit (CVC) values assume a linear increase in nominal levels
Maximum CVC values	CVC values at maximum nominal levels
NPRM EV tax credits	CVC and AMPC at NPRM levels
HDPUV No ZEV	No BEVs added in response to California's ACT program

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Chapters 3 and 9 of the accompanying FRIA summarize results for the alternative baseline and sensitivity cases, and detailed model inputs and outputs for curious readers are available on NHTSA's website.[947] For purposes of this preamble, the figures in Section V.D.1 illustrate the relative change of the sensitivity effect of selected inputs on the costs and benefits estimated for this rule for LDVs, while the figures in Section V.D.2 present the same data for the HDPUV analysis. Each collection of figures groups sensitivity cases by the category of input assumption (*e.g.,* macroeconomic assumptions, technology assumptions, and so on).

While the figures in this section do not show precise values, they give us a sense of which inputs are ones for which a different assumption would have a much different effect on analytical findings, and which ones would not have much effect. For example, assuming a different oil price trajectory would have a relatively large effect, as would doubling, or eliminating the assumed ''payback period.'' Sensitivity analyses also allow us to examine the impact of specific changes from the proposal on our findings. For example, in the final rule analysis, NHTSA used estimates of the social costs of greenhouse gases produced by the EPA, whereas these inputs were taken from the IWG in the proposal. This has a significant impact on net benefits, though they would remain strongly positive regardless of which set of estimates was used. The relative magnitude of these effects also varies by fleet. Making alternative assumptions about the future costs of battery technology has a larger effect on the HDPUV results. Adjusting assumptions related to the tax credits included in the IRA has a significant impact on results for both LDVs and HDPUVs. On the other hand, assumptions about which there has been significant disagreement in the past, like the rebound effect or the sales-scrappage response to changes in vehicle price, appear to cause only relatively small changes in net benefits across the range of analyzed input values. Chapter 9 of the FRIA provides an extended discussion of these findings, and presents net benefits estimated under each of the cases included in the sensitivity analysis.

The results presented in the earlier subsections of Section V and discussed in Section VI reflect NHTSA's best judgments regarding many different factors, and the sensitivity analysis discussed here is simply to illustrate the obvious, that differences in assumptions can lead to differences in analytical outcomes, some of which can be large and some of which may be smaller than expected. Policymaking in the face of future uncertainty is inherently complex. Section VI explains how NHTSA balances the statutory factors in light of the analytical findings, the uncertainty that we know exists, and our nation's policy goals, to set CAFE standards for model years 2027–2031, and HDPUV fuel efficiency standards for model year 2030 and beyond that NHTSA concludes are maximum feasible.

1. Passenger Cars and Light Trucks

Overall, NHTSA finds that for light duty vehicles, the preferred alternative PC2LT002 produces positive societal net benefits for each sensitivity and alternative baseline at both 3 and 7 percent discount rates. Societal net benefits are highest in the ''No payback period'' case ($33 billion) and lowest in the ''Standard-setting conditions for MY 2023–2050'' case ($7.7 billion) at a 3 percent social discount rate and 2 percent SC–GHG discount rate.

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[947] NHTSA. 2023. Corporate Average Fuel Economy. Available at: *https://www.nhtsa.gov/laws-regulations/corporate-average-fuel-economy.* (Accessed: Feb. 23, 2024).

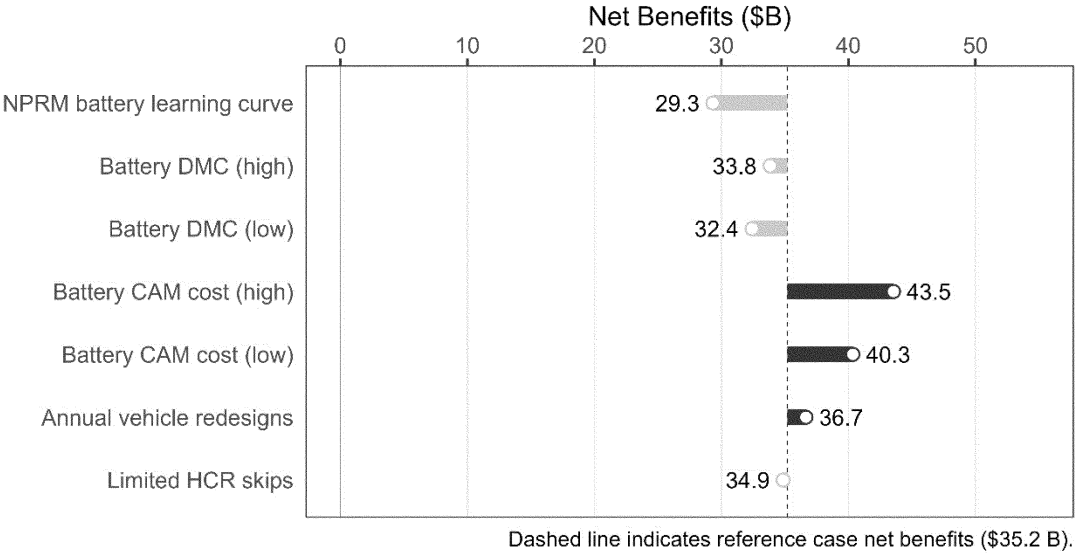

Figure V-21: Net Social Benefits for Lifetime of Vehicles through MY 2031, Alternative PC2LT002 Relative to the Reference Baseline, Technology Assumptions Sensitivity Cases (2021$, 3% social DR, 2% SC-GHG DR)

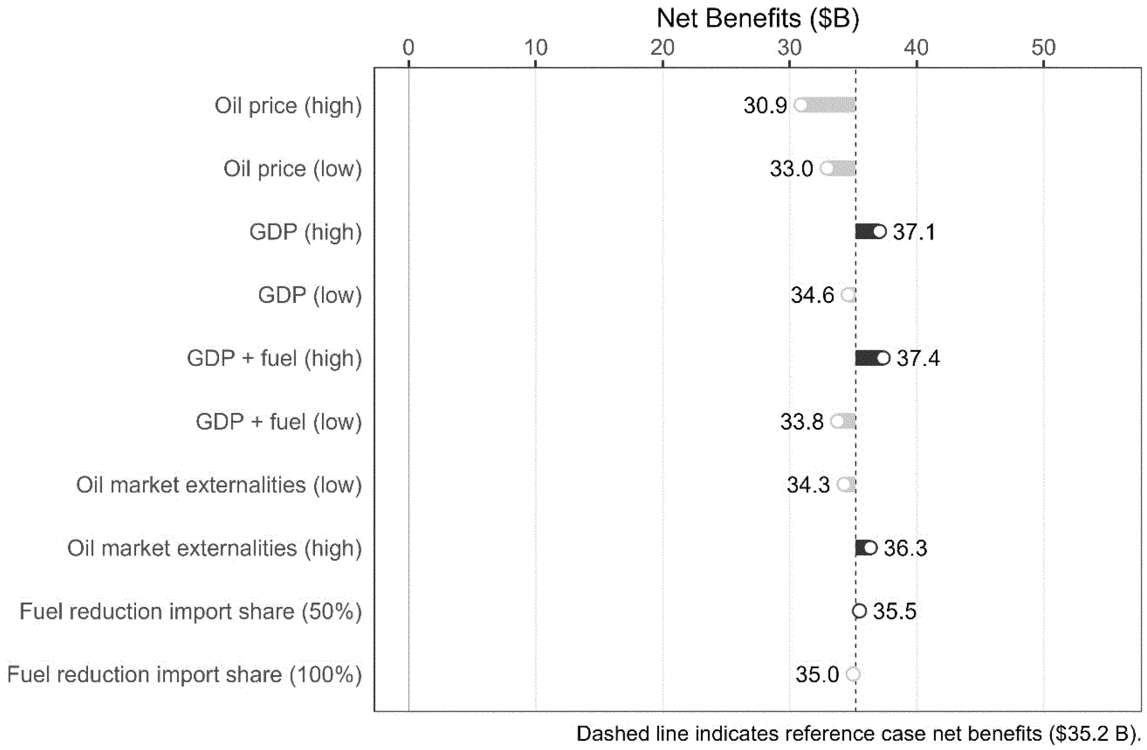

Figure V-22: Net Social Benefits for Lifetime of Vehicles through MY 2031, Alternative PC2LT002 Relative to the Reference Baseline, Macroeconomic Assumptions Sensitivity Cases (2021$, 3% social DR, 2% SC-GHG DR)

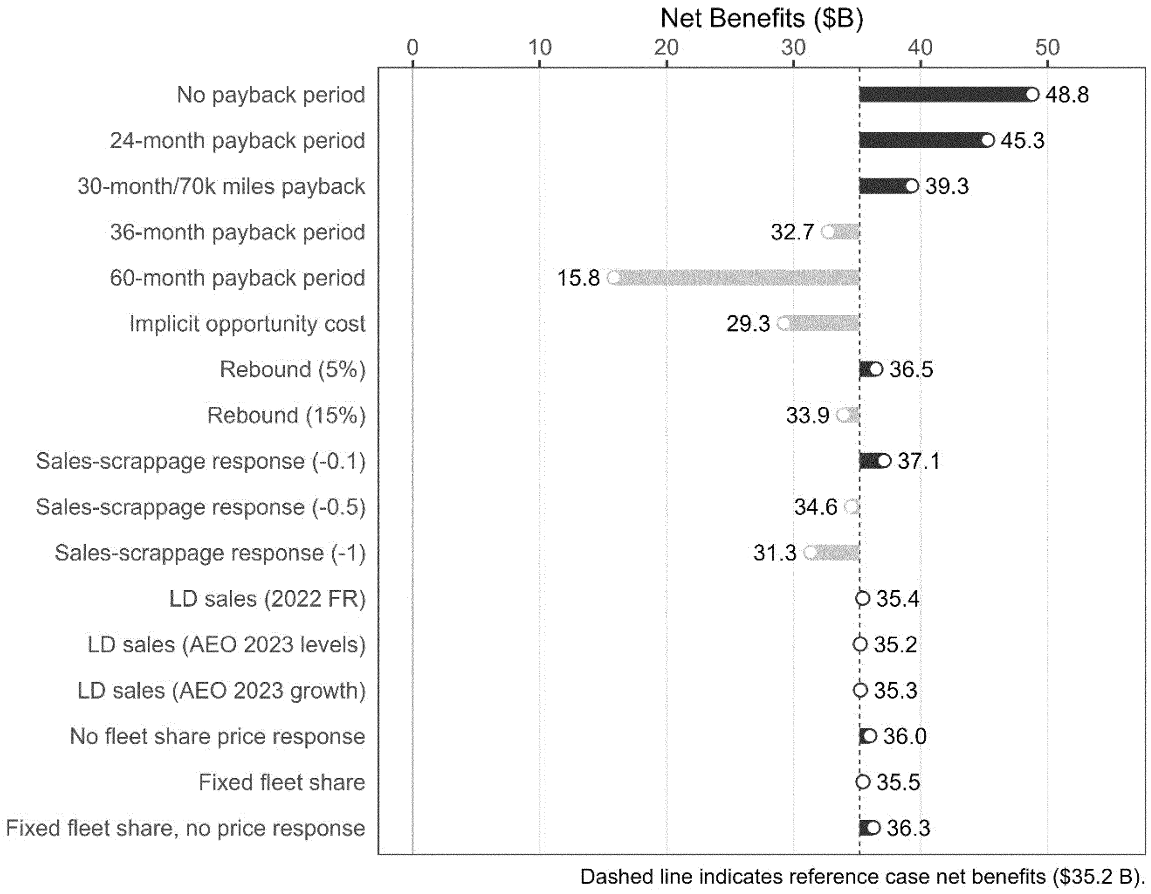

Figure V-23: Net Social Benefits for Lifetime of Vehicles through MY 2031, Alternative PC2LT002 Relative to the Reference Baseline, Payback and Sales Assumptions Sensitivity Cases and Alternative Baseline (2021$, 3% social DR, 2% SC-GHG DR)

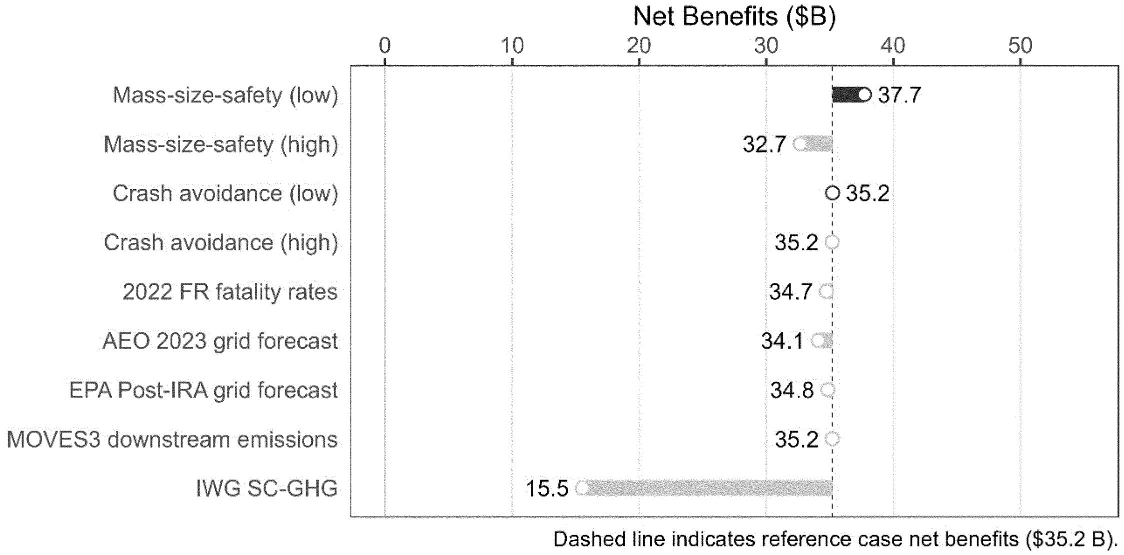

Figure V-24: Net Social Benefits for Lifetime of Vehicles through MY 2031, Alternative PC2LT002 Relative to the Reference Baseline, Social and Environmental Assumptions Sensitivity Cases and Alternative Baseline (2021$, 3% social DR, 2% SC-GHG DR)

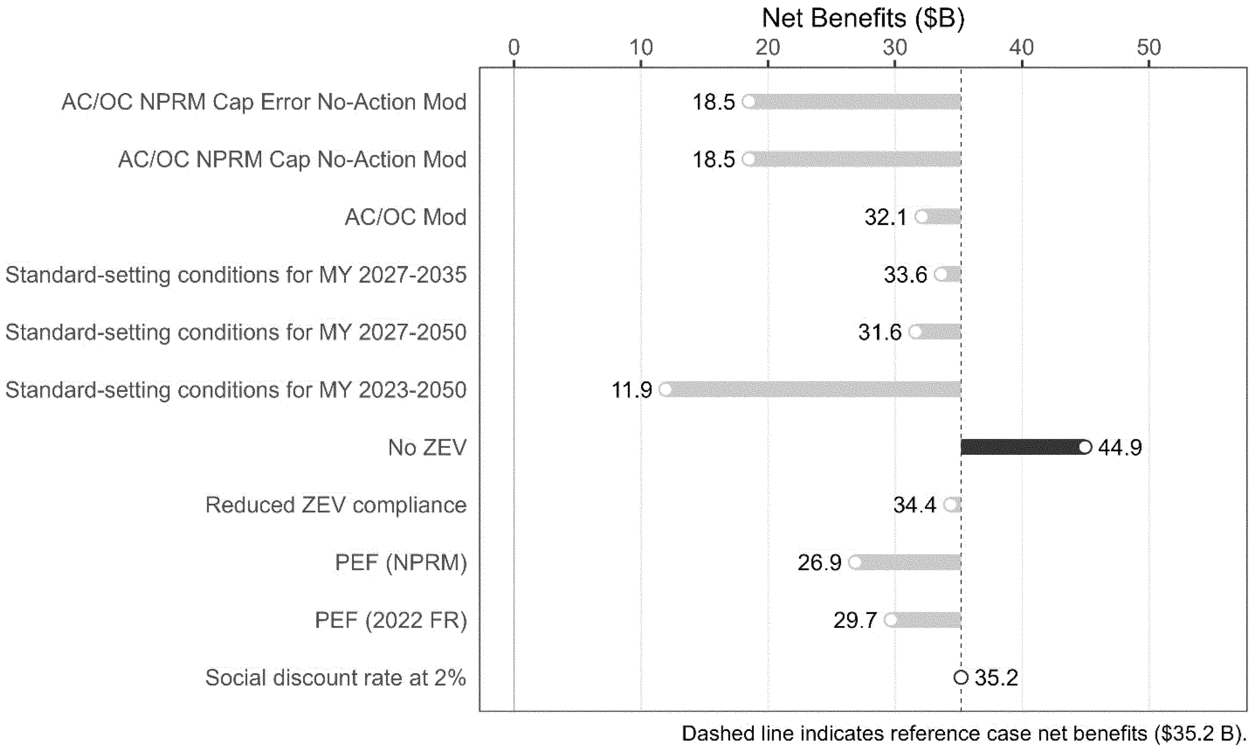

Figure V-25: Net Social Benefits for Lifetime of Vehicles through MY 2031, Alternative PC2LT002 Relative to the Reference Baseline, Policy Assumptions Sensitivity Cases (2021$, 3% social DR, 2% SC-GHG DR)

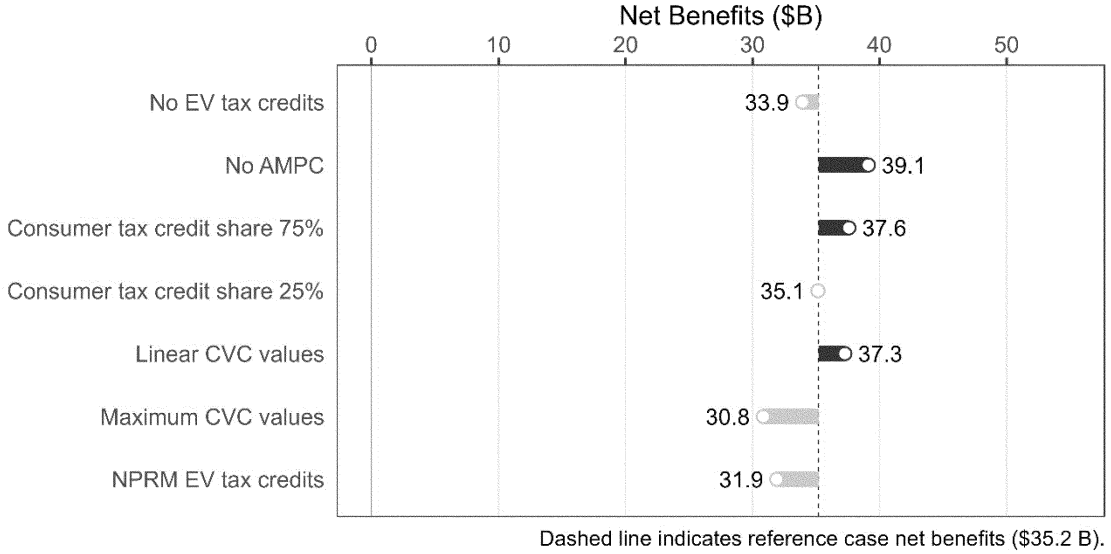

Figure V-26: Net Social Benefits for Lifetime of Vehicles through MY 2031, Alternative PC2LT002 Relative to the Reference Baseline, EV Tax Credit Assumptions Sensitivity Cases (2021$, 3% social DR, 2% SC-GHG DR)

2. Heavy-Duty Pickups and Vans

In our HDPUV analysis the preferred alternative HDPUV108 produces positive net benefits for all but a handful of cases. In these cases, the alternative assumptions lead to greater technology adoption in the No-Action Alternative and lead to net benefits that are just below 0.

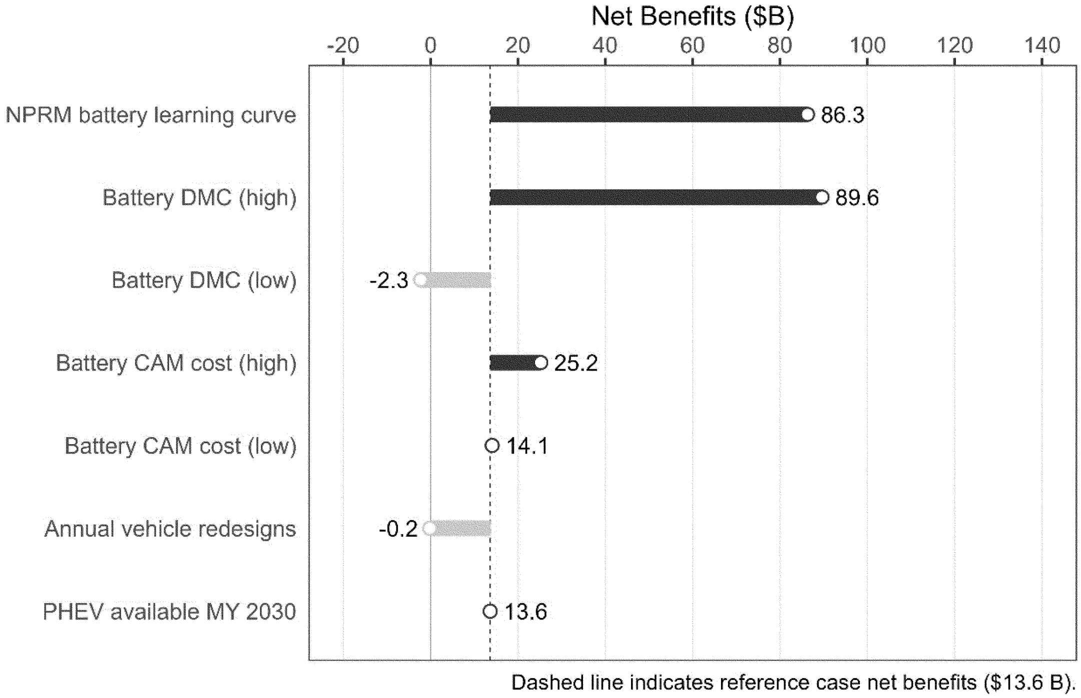

Figure V-27: Net Social Benefits for the On-Road Fleet CYs 2022-2050, Alternative HDPUV108 Relative to the Reference Baseline, Technology Assumptions Sensitivity Cases (2021$, 3% social DR, 2.% SC-GHG DR)

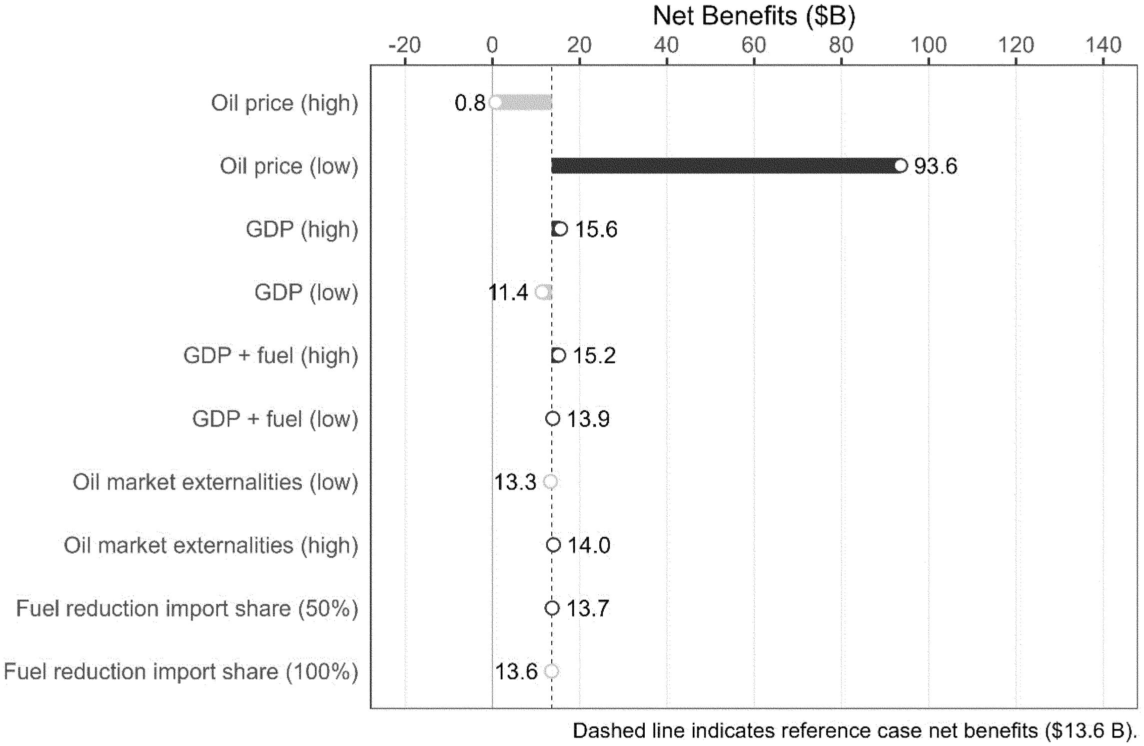

Figure V-28: Net Social Benefits for the On-Road Fleet CYs 2022-2050, Alternative HDPUV108 Relative to the Reference Baseline, Macroeconomic Assumptions Sensitivity Cases (2021$, 3% social DR, 2% SC-GHG DR)

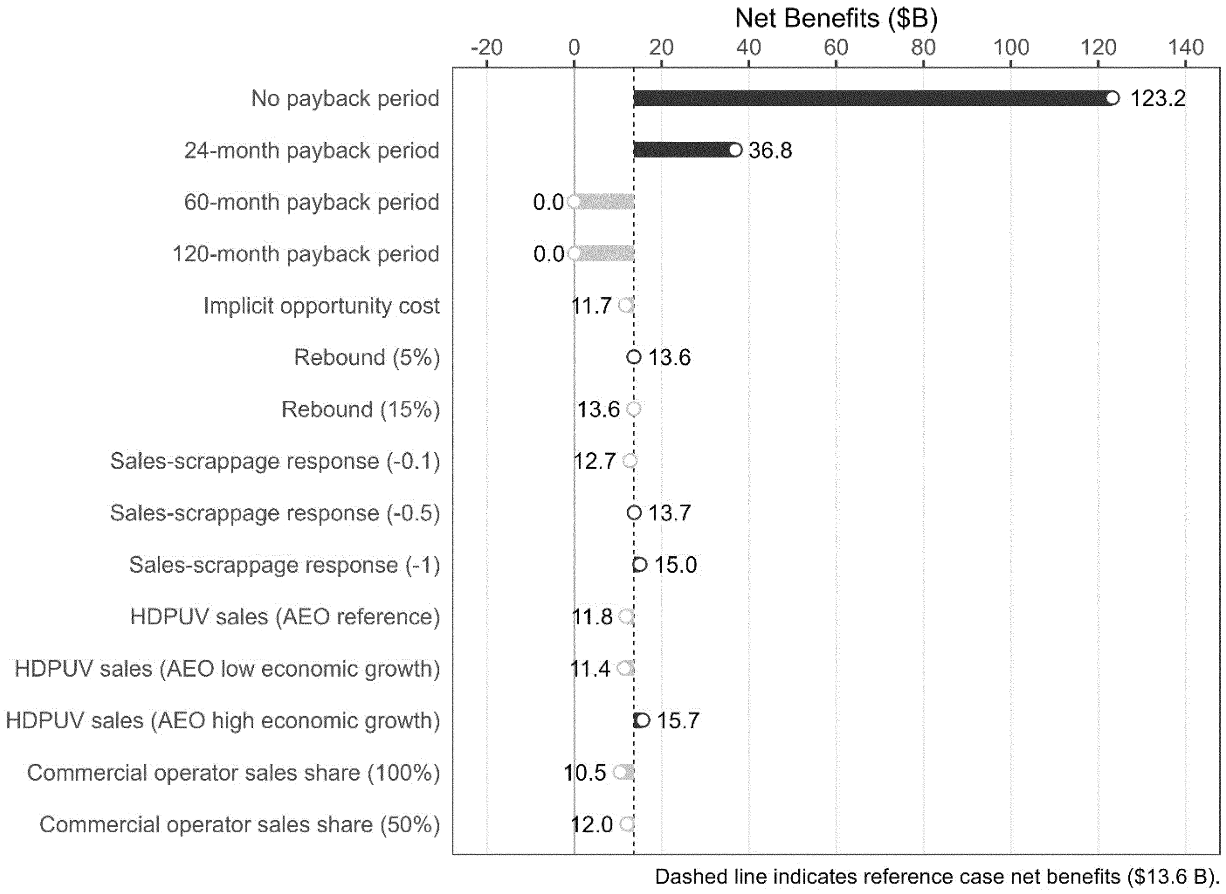

Figure V-29: Net Social Benefits for the On-Road Fleet CYs 2022-2050, Alternative HDPUV108 Relative to the Reference Baseline, Sales and Payback Assumptions Sensitivity Cases (2021$, 3% social DR, 2% SC-GHG DR)

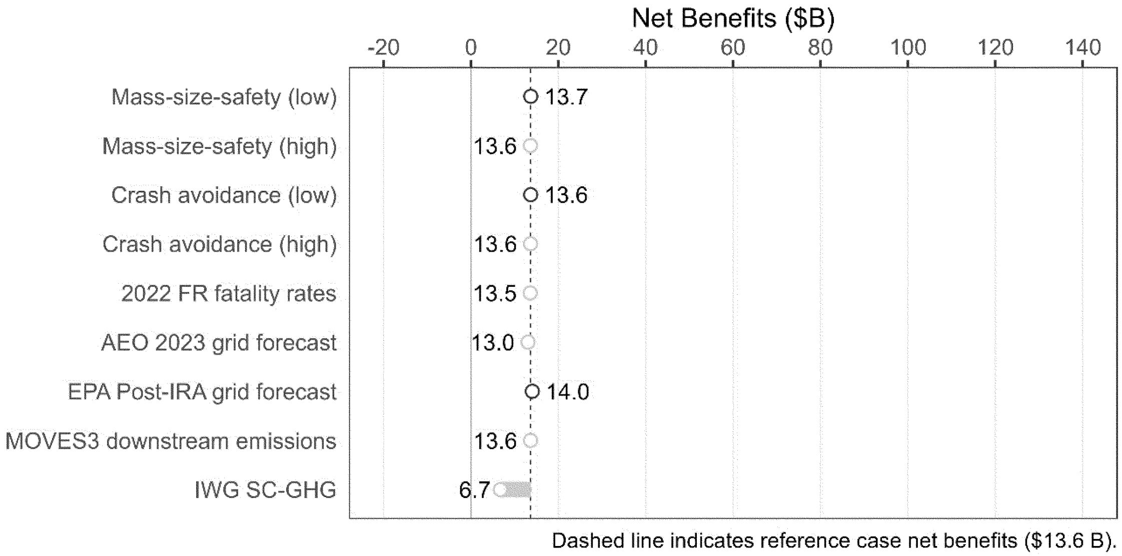

Figure V-30: Net Social Benefits for the On-Road Fleet CYs 2022-2050, Alternative HDPUV108 Relative to the Reference Baseline, Social and Environmental Assumptions Sensitivity Cases and Alternative Baseline (2021$, 3% social DR, 2% SC-GHG DR)

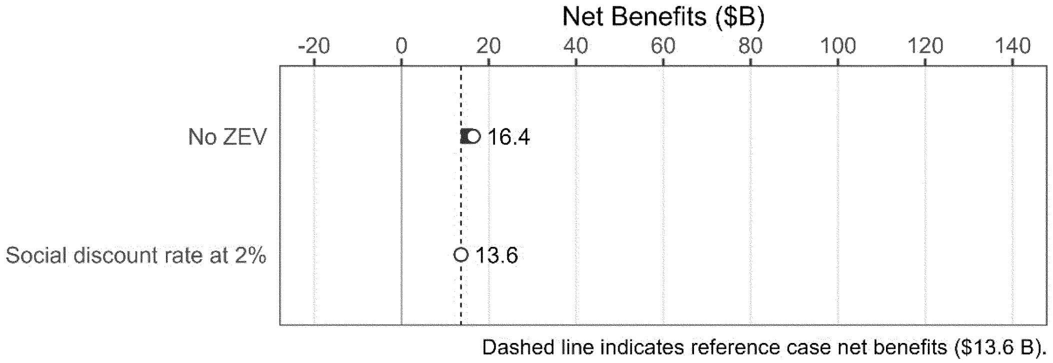

Figure V-31: Net Social Benefits for the On-Road Fleet CYs 2022-2050, Alternative HDPUV108 Relative to the Reference Baseline, Policy Assumptions Sensitivity Cases (2021$, 3% social DR, 2% SC-GHG DR)

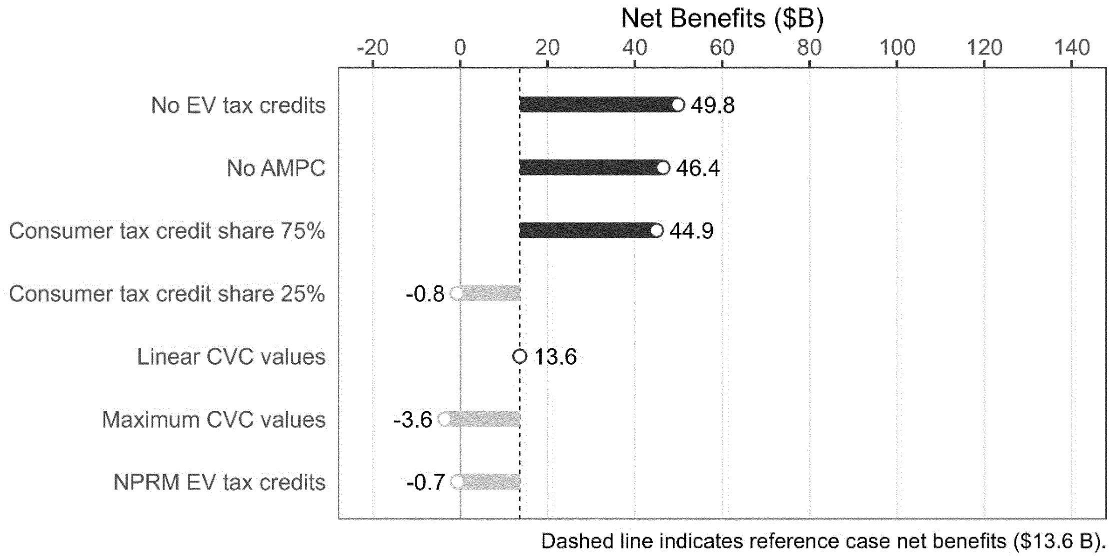

Figure V-32: Net Social Benefits for the On-Road Fleet CYs 2022-2050, Alternative HDPUV108 Relative to the Reference Baseline, EV Tax Credit Assumptions Sensitivity Cases (2021$, 3% social DR, 2% SC-GHG DR)

VI. Basis for NHTSA's Conclusion That the Standards Are Maximum Feasible

NHTSA's purpose in setting CAFE standards is to conserve energy, as directed by EPCA/EISA. Energy conservation provides many benefits to the American public, including better protection for consumers against changes in fuel prices, significant fuel savings and reduced impacts from harmful pollution. NHTSA continues to believe that fuel economy standards can function as an important insurance policy against oil price volatility, particularly to protect consumers even as the U.S. has improved its energy independence over time. Although NHTSA proposed PC2LT4 as the preferred alternative for CAFE standards for model years 2027–2031, NHTSA is finalizing PC2LT002 for those model years. Based on comments received and a closer look at the model results under the statutorily-constrained analysis, NHTSA now concludes that ''shortfalls'' and civil penalties must be managed in order to conserve manufacturer capital and resources for making the technological transition that NHTSA is prohibited from considering directly.

Similarly, for HDPUV, while NHTSA proposed HDPUV10 for model years 2030–2035, NHTSA is finalizing HDPUV108 for those model years. Based on comments received and a closer look at the model results—and specifically, as in the NPRM, the sensitivity analyses, as well as the apparent effects on certain manufacturers—NHTSA recognizes that uncertainty, particularly in the later model years of the rulemaking, means that a slower rate of increase is maximum feasible for those years. These conclusions, for both passenger cars and light trucks and for HDPUVs, will be discussed in more detail below.

A. EPCA, as Amended by EISA

EPCA, as amended by EISA, contains provisions establishing how NHTSA must set CAFE standards and fuel efficiency standards for HDPUVs. DOT (by delegation, NHTSA)[948] must establish separate CAFE standards for passenger cars and light trucks for each model year,[949] [950] and each standard must be the maximum feasible that the Secretary (again, by delegation, NHTSA) determines manufacturers can achieve in that model year.[951] In determining the maximum feasible levels of CAFE standards, EPCA requires that NHTSA consider four statutory factors: technological feasibility, economic practicability, the effect of other motor vehicle standards of the Government on fuel economy, and the need of the United States to conserve energy.[952] NHTSA must also set separate standards for HDPUVs, and while those standards must also ''achieve the maximum feasible improvement,'' they must be ''appropriate, cost-effective, and technologically feasible'' [953]—factors slightly different from those required to be considered for passenger car and light truck standards. NHTSA has broad discretion to balance the statutory factors in developing fuel consumption standards to achieve the maximum feasible improvement. In addition, NHTSA has the authority to consider (and typically does consider) other relevant factors, such as the effect of CAFE standards on motor vehicle safety.

The ultimate determination of what standards can be considered maximum feasible involves a weighing and balancing of factors, and the balance may shift depending on the information NHTSA has available about the expected circumstances in the model years covered by the rulemaking. NHTSA's decision must also be guided by the overarching purpose of EPCA, energy conservation, while balancing these factors.[954]

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[948] EPCA and EISA direct the Secretary of Transportation to develop, implement, and enforce fuel economy standards (*see* 49 U.S.C. 32901 *et seq.*), which authority the Secretary has delegated to NHTSA at 49 FR 1.95(a).

[949] 49 U.S.C. 32902(b)(1) (2007).

[950] 49 U.S.C. 32902(a) (2007).

[951] *Id.*

[952] 49 U.S.C. 32902(f).

[953] 49 U.S.C. 32902(k)(2).

[954] *Center for Biological Diversity* v. *NHTSA,* 538 F.3d 1172, 1197 (9th Cir. 2008) (''Whatever method it uses, NHTSA cannot set fuel economy standards

Continued

EPCA/EISA also contain several other requirements, as follows.

1. Lead Time

a. Passenger Cars and Light Trucks

EPCA requires that NHTSA prescribe new CAFE standards at least 18 months before the beginning of each model year.[955] Thus, if the first year for which NHTSA is establishing new CAFE standards is model year 2027, NHTSA interprets this provision as requiring us to issue a final rule covering model year 2027 standards no later than April 2025. No specific comments were received regarding the 18-month lead time requirement for CAFE standards, although ZETA and Hyundai commented that NHTSA should wait to finalize the CAFE standards until after DOE finalized the PEF revision, out of concern that failing to do so would ''increase administrative burden for both'' agencies,[956] and that NHTSA's final rule would not otherwise ''accurately reflect the final PEF.'' [957] Because NHTSA coordinated with DOE as both agencies worked to finalize their respective rules, this final rule reflects DOE's final PEF. Given that the Deputy Administrator of NHTSA signed this final rule in June 2024, the statutory lead time requirement is met.

b. Heavy-Duty Pickups and Vans

EISA requires that standards for commercial medium- and HD on-highway vehicles and work trucks (of which HDPUVs are part) provide not less than four full model years of regulatory lead time.[958] Thus, if the first year for which NHTSA is establishing new fuel efficiency standards for HDPUVs is model year 2030, NHTSA interprets this provision as requiring us to issue a final rule covering model year 2030 standards no later than October 2025.[959] Stellantis commented that it agreed with the proposal, that in order to provide four full model years of regulatory lead time, the earliest model year for which NHTSA could establish new standards was model year 2030.[960] NHTSA agrees and is establishing new standards for HDPUVs beginning in model year 2030. This means that the applicable model years of NHTSA's final rule do not align perfectly with EPA's recent final rule establishing multipollutant (including GHG) standards for the same vehicles, but this is a direct consequence of the statutory lead time requirement in EISA. The Alliance and GM also agreed in their comments that model year 2030 was an appropriate start year for new HDPUV standards.[961] GM stated that that timeframe ''would provide manufacturers sufficient lead time to adjust product plans to standards.'' [962] Given that the Deputy Administrator of NHTSA signed this final rule in June, 2024, this lead time requirement is met.

EISA contains a related requirement for HDPUVs that the standards provide not only four full model years of regulatory lead time, but also three full model years of regulatory stability.[963] As discussed in the Phase 2 final rule, Congress has not spoken directly to the meaning of the words ''regulatory stability.'' NHTSA interprets the ''regulatory stability'' requirement as ensuring that manufacturers will not be subject to new standards in repeated rulemakings too rapidly, given that Congress did not include a minimum duration period for the MD/HD standards.[964] NHTSA further interprets the statutory meaning as reasonably encompassing standards which provide for increasing stringency during the rulemaking time frame to be the maximum feasible. In this statutory context, NHTSA thus interprets the phrase ''regulatory stability'' in section 32902(k)(3)(B) as requiring that the standards remain in effect for three years before they may be increased by amendment. It does not prohibit standards that contain predetermined stringency increases.

CEA commented that this interpretation was inconsistent with the law. It stated that a standard could not be ''stable'' if it ''continually ratchets up each year,'' and argued that HDPUV redesign cycles are longer than light truck redesign cycles and that ''manufacturers would therefore have difficulty meeting standards that ratchet up every year.'' [965] In response, NHTSA continues to believe that ''stable'' can reasonably be interpreted as ''known in advance'' and ''remaining in effect for three years,'' in part because the dictionary provides definitions for ''stable'' that include ''firmly established; fixed; steadfast; enduring.'' [966] While some definitions of ''stable'' mention ''not changing or fluctuating; unvarying,'' [967] NHTSA believes that standards that are known in advance and established in three-year tranches can reasonably fit these definitions—the standards will not change or vary from what is established here, except by rulemaking as necessary (and as permissible given lead time requirements). EISA does not suggest that NHTSA interpret ''unvarying'' as exclusively suggesting that ''standards may only increase once every three years and then must be held at that level,'' and could also be reasonably read to suggest that ''standards should not change from established levels, once established.'' NHTSA is accordingly establishing new HDPUV standards in two tranches: standards that increase 10 percent per year for model years 2030–2031–2032, and standards that increase at 8 percent per year for model years 2033–2034–2035.

NHTSA also believes, based on comments, that redesign cycles should not be a problem for the HDPUV standards. NHTSA notes the comment from GM, mentioned above, that NHTSA beginning new standards in model year 2030 will provide sufficient lead time for manufacturers to adjust their product plans as needed, even while GM also noted that redesign cycles were longer for HDPUVs than for LTs.[968] GM further stated that the lead time provided ''lowers the likelihood of product disruptions in the market.'' [969] NHTSA agrees that HDPUV redesign cycles are longer than light truck redesign cycles and reflects this in our analysis, which shows the final standards (and indeed, all of the alternatives) as being achievable for the entirety of the HDPUV fleet, with no shortfalls under any regulatory alternative:

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that are contrary to Congress's purpose in enacting the EPCA—energy conservation.''). While this decision applied only to standards for passenger cars and light trucks, NHTSA interprets the admonition as broadly applicable to its actions under section 32902.

[955] 49 U.S.C. 32902(a) (2007).

[956] ZETA, Docket No. NHTSA–2023–0022–60508, at 28.

[957] Hyundai, Docket No. NHTSA–2023–0022–51701, at 6.

[958] 49 U.S.C. 32902(k)(3)(A) (2007).

[959] As with passenger cars and light trucks, NHTSA interprets the model year for HDPUVs as beginning with October of the calendar year prior. Therefore, HDPUV model year 2029 would begin in October 2028; therefore, four full model years prior to October 2028 would be October 2024.

[960] Stellantis, Docket No. NHTSA–2023–0022–61107, at 12.

[961] The Alliance, Docket No. NHTSA–2023–0022–60652, Attachment 3, at 52; GM, Docket No. NHTSA–2023–0022–60686, at 7.

[962] GM, Docket No. NHTSA–2023–0022–60686, at 7.

[963] 49 U.S.C. 32902(k)(3)(B) (2007).

[964] In contrast, as discussed below, passenger car and standards must remain in place for ''at least 1, but not more than 5, model years.'' 49 U.S.C. 32902(b)(3)(B).

[965] CEA, Docket No. NHTSA–2023–0022–61918, at 31.

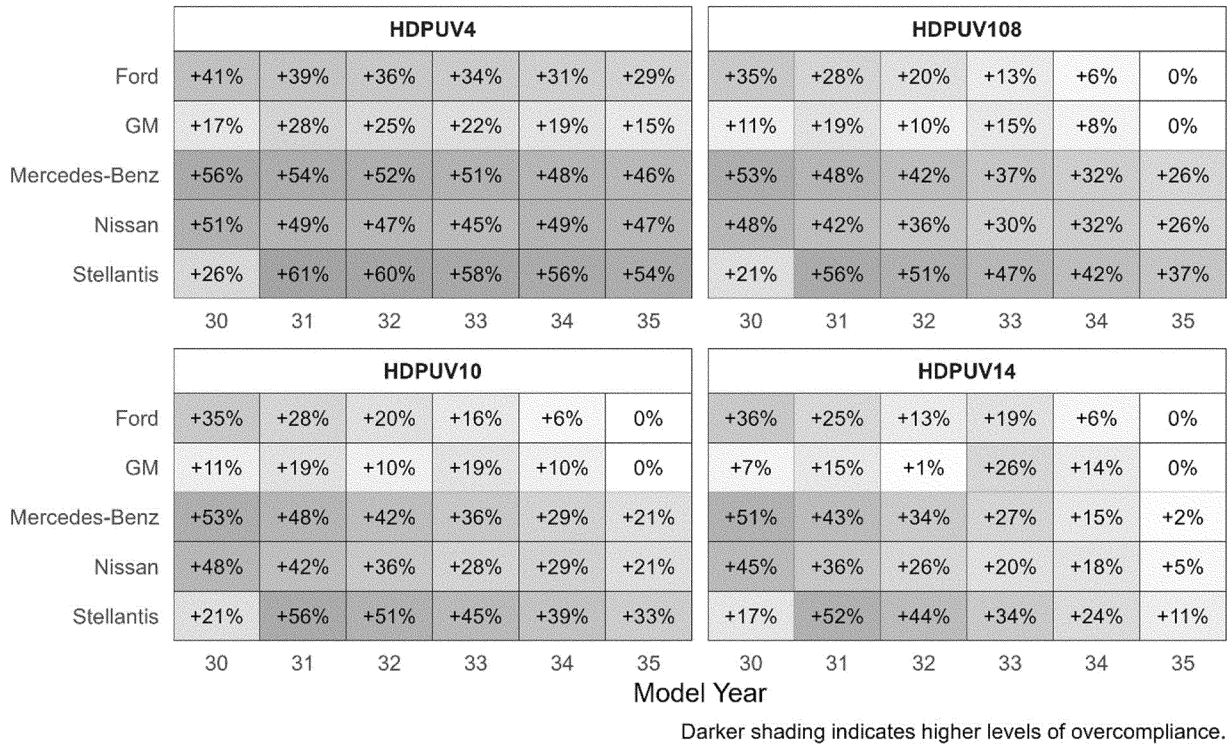
[966] *https://www.merriam-webster.com/dictionary/stable* (last accessed Apr. 15, 2024).

[967] *Id.*

[968] GM, Docket No. NHTSA–2023–0022–60686, at 7.

[969] *Id.*

Figure VI-1: HDPUV Fleet Achieved Fuel Efficiency Relative to Standard



HDPUV4

	30	31	32	33	34	35
Ford	+41%	+39%	+36%	+34%	+31%	+29%
GM	+17%	+28%	+25%	+22%	+19%	+15%
Mercedes-Benz	+56%	+54%	+52%	+51%	+48%	+46%
Nissan	+51%	+49%	+47%	+45%	+49%	+47%
Stellantis	+26%	+61%	+60%	+58%	+56%	+54%

HDPUV108

	30	31	32	33	34	35
Ford	+35%	+28%	+20%	+13%	+6%	0%
GM	+11%	+19%	+10%	+15%	+8%	0%
Mercedes-Benz	+53%	+48%	+42%	+37%	+32%	+26%
Nissan	+48%	+42%	+36%	+30%	+32%	+26%
Stellantis	+21%	+56%	+51%	+47%	+42%	+37%

HDPUV10

	30	31	32	33	34	35
Ford	+35%	+28%	+20%	+16%	+6%	0%
GM	+11%	+19%	+10%	+19%	+10%	0%
Mercedes-Benz	+53%	+48%	+42%	+36%	+29%	+21%
Nissan	+48%	+42%	+36%	+28%	+29%	+21%
Stellantis	+21%	+56%	+51%	+45%	+39%	+33%

HDPUV14

	30	31	32	33	34	35
Ford	+36%	+25%	+13%	+19%	+6%	0%
GM	+7%	+15%	+1%	+26%	+14%	0%
Mercedes-Benz	+51%	+43%	+34%	+27%	+15%	+2%
Nissan	+45%	+36%	+26%	+20%	+18%	+5%
Stellantis	+17%	+52%	+44%	+34%	+24%	+11%

Darker shading indicates higher levels of overcompliance.

This approach is consistent with our understanding of regulatory stability. Manufacturers appear likely to have little to zero difficulty in meeting the final standards. Setting HDPUV standards that did not increase for three years instead would make little functional difference to compliance, given the availability of credit banking.

2. Separate Standards for Passenger Cars, Light Trucks, and Heavy-Duty Pickups and Vans, and Minimum Standards for Domestic Passenger Cars

EPCA requires NHTSA to set separate standards for passenger cars and light trucks for each model year.[970] Based on the plain language of the statute, NHTSA has long interpreted this requirement as preventing NHTSA from setting a single combined CAFE standard for cars and trucks together. Congress originally required separate CAFE standards for cars and trucks to reflect the different fuel economy capabilities of those different types of vehicles, and over the history of the CAFE program, has never revised this requirement. Even as many cars and trucks have come to resemble each other more closely over time—many crossover and sport-utility models, for example, come in versions today that may be subject to either the car standards or the truck standards depending on their characteristics—it is still accurate to say that vehicles with truck-like characteristics such as 4-wheel drive, cargo-carrying capability, etc., currently consume more fuel per mile than vehicles without these components. While there have been instances in recent rulemakings where NHTSA raised passenger car and light truck standard stringency at the same numerical rate year over year, NHTSA also has precedent for setting passenger car and light truck standards that increase at different numerical rates year over year, as in the 2012 final rule. This underscores that NHTSA's obligation is to set maximum feasible standards separately for each fleet, based on our assessment of each fleet's circumstances as seen through the lens of the four statutory factors that NHTSA must consider. Regarding the applicability of the CAFE standards, individual citizens commenting via Climate Hawks Civic Action asked whether U.S. Postal Service vehicles,[971] airplanes,[972] and non-road engines (such as for lawn equipment)[973] could also be subject to CAFE standards. Postal Service vehicles are generally HDPUVs, and thus subject to those standards rather than to CAFE standards. Airplanes and non-road engines are not automobiles under 49 U.S.C. 32901, so they cannot be subject to CAFE standards. An individual citizen with Climate Hawks Civic Action also requested that NHTSA *not* set separate standards for light trucks, on the basis that doing so would be detrimental to energy conservation.[974] As explained above, NHTSA interprets 49 U.S.C. 32902 as requiring NHTSA to set separate standards for passenger cars and light trucks. Again, NHTSA does not believe that it has statutory authority to set a single standard for both passenger cars and light trucks.

EPCA, as amended by EISA, also requires another separate standard to be set for domestically manufactured passenger cars.[975] Unlike the generally applicable standards for passenger cars and light trucks described above, the compliance obligation of the minimum

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[970] 49 U.S.C. 32902(b)(1) (2007).

[971] Climate Hawks, Docket No. NHTSA–2023–0022–61094, at 182.

[972] *Id.* at 2244.

[973] *Id.* at 2520.

[974] *Id.* at 2579.

[975] In the CAFE program, ''domestically manufactured'' is defined by Congress in 49 U.S.C. 32904(b). The definition roughly provides that a passenger car is ''domestically manufactured'' as long as at least 75 percent of the cost to the manufacturer is attributable to value added in thie United States, Canada, or Mexico, unless the assembly of the vehicle is completed in Canada or Mexico *and* the vehicle is imported into the United States more than 30 days after the end of the model year.

domestic passenger car standard (MDPCS) is identical for all manufacturers. The statute clearly states that any manufacturer's domestically manufactured passenger car fleet must meet the greater of either 27.5 mpg on average, or ''92 percent of the average fuel economy projected by the Secretary for the combined domestic and non-domestic passenger automobile fleets manufactured for sale in the United States by all manufacturers in the model year, which projection shall be published in the **Federal Register** when the standard for that model year is promulgated in accordance with [49 U.S.C. 32902(b)].'' [976] Since that statutory requirement was established, the ''92 percent'' has always been greater than 27.5 mpg, and foreseeably will continue to be so in the future. As in the 2020 and 2022 final rules, NHTSA continues to recognize industry concerns that actual total passenger car fleet standards have differed significantly from past projections, perhaps more so when NHTSA has projected significantly into the future. In the 2020 final rule, the compliance data showed that standards projected in the 2012 final rule were consistently more stringent than the actual standards as calculated at the end of the model year, by an average of 1.9 percent. NHTSA has stated that this difference indicates that in rulemakings conducted in 2009 through 2012, NHTSA's and EPA's projections of passenger car vehicle footprints and production volumes, in retrospect, underestimated the production of larger passenger cars over the model years 2011 to 2018 period.[977]

Unlike the passenger car standards and light truck standards which are vehicle-attribute-based and automatically adjust with changes in consumer demand, the MDPCS are not attribute-based, and therefore do not adjust with changes in consumer demand and production. They are, instead, fixed standards that are established at the time of the rulemaking. As a result, by assuming a smaller-footprint fleet, on average, than what ended up being produced, the model year 2011–2018 MDPCS ended up being more stringent and placing a greater burden on manufacturers of domestic passenger cars than was projected and expected at the time of the rulemakings that established those standards. In the 2020 final rule, therefore, NHTSA agreed with industry concerns over the impact of changes in consumer demand (as compared to what was assumed in 2012 about future consumer demand for greater fuel economy) on manufacturers' ability to comply with the MDPCS and in particular, manufacturers that produce larger passenger cars domestically. Some of the largest civil penalties for noncompliance in the history of the CAFE program have been paid for noncompliance with the MDPCS.[978] NHTSA also expressed concern at that time that consumer demand may shift even more in the direction of larger passenger cars if fuel prices continue to remain low. Sustained low oil prices can be expected to have real effects on consumer demand for additional fuel economy, and if that occurs, consumers may foreseeably be even more interested in 2WD crossovers and passenger-car-fleet SUVs (and less interested in smaller passenger cars) than they are at present.

Therefore, in the 2020 final rule, to help avoid similar outcomes in the 2021 to 2026 time frame to what had happened with the MDPCS over the preceding model years, NHTSA determined that it was reasonable and appropriate to consider the recent projection errors as part of estimating the total passenger car fleet fuel economy for model years 2021–2026. NHTSA therefore projected the total passenger car fleet fuel economy using the central analysis value in each model year, and applied an offset based on the historical 1.9 percent difference identified for model years 2011–2018.

For the 2022 final rule, NHTSA retained the 1.9 percent offset, concluding that it is difficult to predict passenger car footprint trends in advance, which means that, as various stakeholders have consistently noted, the MDPCS may turn out quite different from 92 percent of the ultimate average passenger car standard once a model year is complete. NHTSA also expressed concern, as suggested by the United Automobile, Aerospace, and Agricultural Implement Workers of America (UAW), that automakers struggling to meet the unadjusted MDPCS may choose to import their passenger cars rather than producing them domestically.

In the NPRM, NHTSA proposed to continue employing the 1.9 percent offset for model years 2027–2032, stating that NHTSA continued to believe that the reasons presented previously for the offset still apply, and that therefore the offset is appropriate, reasonable, and consistent with Congress' intent.

The Alliance, Ford, Nissan, and Kia commented that retaining the MDPCS offset was appropriate.[979] Kia, for example, stated that it helped manufacturers avoid civil penalty payments, but expressed concern that the stringency of the proposed passenger car standards was so high that ''even strong hybrids may not achieve the proposed MDPCS in the outer years.'' [980] Despite the offset, Kia suggested that this overall passenger car stringency could ''complicate'' Kia's continued ability to produce passenger cars in the United States.[981]

The States and Cities commented that while the offset to the MDPCS was not ''inherently unreasonable,'' they disagreed with NHTSA's interpretation of 32902(b)(4). Specifically, they argued that ''the average fuel economy *projected* by the Secretary for the combined domestic and non-domestic passenger car fleets . . .'' should be interpreted to refer to the estimated *achieved* value rather than (as NHTSA has long interpreted it) to the estimated *required* value.[982] The States and Cities commented that this reading was closer to the plain language of the statute, and asked NHTSA to clarify in the final rule that the offset was a ''*proxy* for the required projected average, [rather than] an interpretation away from the plain statutory text.'' [983] The States and Cities further requested that the offset, if any, be calculated as ''the difference between the previous model years' central analysis value and average fuel economies *achieved,* rather than the difference between the projected and actual fleet-average standard.'' [984]

NHTSA has interpreted ''projected'' as referring to estimated *required* levels rather than estimated *achieved* levels since at least 2010. In the final rule establishing CAFE standards for model years 2012–2016, NHTSA noted that the Alliance had requested in its comments that the MDPCS be based on estimated achieved values.[985] NHTSA responded that because Congress referred in the second clause of 32904(b)(4)(B) to the *standard* promulgated for that model year, therefore NHTSA interpreted the

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[976] 49 U.S.C. 32902(b)(4) (2007).

[977] *See* 85 FR 25127 (Apr. 30, 2020).

[978] *See* the Civil Penalties Report visualization tool at *https://www.nhtsa.gov/corporate-average-fuel-economy/cafe-public-information-center* for more specific information about civil penalties previously paid.

[979] The Alliance, NHTSA–2023–0022–60652, Attachment 2, at 10; Ford, NHTSA–2023–0022–60837, at 10; Nissan, NHTSA–2023–0022–60696, at 9; Kia, NHTSA–2023–0022–58542–A1, at 5.

[980] Kia, Docket No. NHTSA–2023–0022–58542–A1, at 5.

[981] *Id.*

[982] States and Cities, Docket No. NHTSA–2023–0022–61904, Attachment 2, at 41.

[983] *Id.*

[984] *Id.* at 41–42.

[985] *See* 75 FR 25324, 25614 (May 7, 2010).

''projection'' as needing to be based on the estimated required value (*i.e.,* the projection of the standard).[986] The estimated achieved value represents manufacturers' assumed performance against the standard, not the standard itself. NHTSA believes that this logic continues to hold, and thus continues to determine the MDPCS based on the estimated required mpg levels projected for the model years covered by the rulemaking, and to determine the offset based on the estimated required levels rather than on the estimated achieved levels.

That said, NHTSA agrees that the offset is in some ways a proxy for 92 percent of the projected standard, insofar as the future is inherently uncertain and many different factors may combine to result in actual final passenger car mpg values that differ from those estimated as part of this final rule. Vehicle manufacturers may face even more uncertainty in the time frame of this rulemaking than they have faced since the MDPCS offset was first implemented. While NHTSA believes that the overall passenger car standards are maximum feasible based on the discussion in Section VI.D below, in response to Kia's comment that passenger car standard stringency may cause Kia to move its car production offshore, NHTSA continues to believe that the MDPCS offset helps to mitigate that uncertainty and perhaps to ease the major transition through which the industry is passing.

For HDPUVs, Congress gave DOT (by delegation, NHTSA) broad discretion to ''prescribe separate standards for different classes of vehicles'' under 49 U.S.C. 32902(k). HDPUVs are defined by regulation as ''pickup trucks and vans with a gross vehicle weight rating between 8,501 pounds and 14,000 pounds (Class 2b through 3 vehicles) manufactured as complete vehicles by a single or final stage manufacturer or manufactured as incomplete vehicles as designated by a manufacturer.'' [987] NHTSA also allows HD vehicles above 14,000 pounds GVWR to be optionally certified as HDPUVs and comply with HDPUV standards ''if properly included in a test group with similar vehicles at or below 14,000 pounds GVWR,'' and ''The work factor for these vehicles may not be greater than the largest work factor that applies for vehicles in the test group that are at or below 14,000 pounds GVWR.''[988] Incomplete HD vehicles at or below 14,000 pounds GVWR may also be optionally certified as HDPUVs and comply with the HDPUV standards.[989]

GM commented that it was appropriate for NHTSA to set HDPUV standards and passenger car/light truck CAFE standards in the same rulemaking, because electrifying certain light trucks could increase their weight to the point where they become HDPUVs, and ''Conducting these rulemakings together is an important first step to considering this possibility when setting standards.'' [990] In response, NHTSA does track the classification of vehicles in order to ensure that its consideration of potential future CAFE and HDPUV stringencies is appropriately informed, and NHTSA did reassign vehicles from the light truck fleet to the HDPUV fleet (and vice versa) in response to stakeholder feedback to the NPRM. RVIA commented that the NPRM neither considered nor specifically mentioned motorhomes weighing less than 14,000 pounds GVWR, and expressed concern that the new standards would apply to these vehicles and ''require [them] to be electrified.'' [991] In response, the Phase 2 MD/HD final rule explains that these vehicles are properly classified under EISA's definitions as Class 2b–8 vocational vehicles and not as HDPUVs.[992] NHTSA is not setting new standards for vocational vehicles as part of this action. Moreover, as discussed elsewhere in this document, the HDPUV standards are performance-based standards and not electric-vehicle mandates.[993]

AFPM commented that NHTSA ''failed to address any of the unique statutory factors for HDPUVs,'' pointing to 49 U.S.C. 32902(k)(1) and suggesting that NHTSA had not followed that section in developing its proposal.[994] NHTSA agrees that it did not follow 32902(k)(1) in developing its proposal, because NHTSA executed the requirements of that section as part of the Phase 1 MD/HD fuel efficiency rulemaking, completed in 2011. NHTSA's website contains a link to the independent study that NHTSA performed, as directed by 32902(k)(1), following the publication of the NAS report.[995] Because that statutory requirement has been executed, NHTSA did not undertake it again as part of this rulemaking.

NHTSA is establishing separate standards for ''spark ignition'' (SI, or gasoline-fueled) and ''compression ignition'' (CI, or diesel-fueled) HDPUVs, consistent with the existing Phase 2 standards. Each class of vehicles has its own work-factor based target curve; alternative fueled vehicles (such as BEVs) are subject to the standard for CI vehicles and HEVs and PHEVs are subject to the standard for SI vehicles. We understand that EPA has recently finalized a single curve for all HDPUVs regardless of fuel type. ACEEE commented that NHTSA should follow suit and raise the stringency of the gasoline standards to match that of the diesel standards, arguing that it would improve consistency with EPA's program and be consistent with NHTSA's acknowledgement of the emergence of van electrification.[996] NHTSA is not taking this approach, for several reasons. First, EPA is modifying the model year 2027 standards set in the 2016 ''Phase 2'' rulemaking, and NHTSA cannot follow suit due to statutory lead time requirements. Second, EPA's single curve standard developed in GHG gas units (g CO_2/mile) will still result in two separate curves when converted to the units used by NHTSA to set standards for fuel efficiency (gal/100 miles). This is a result of the differing amount of CO_2 released by each fuel type represented by each standard curve. Gasoline releases about 8,887g of CO_2 per gallon burned and diesel fuel releases about 10,180g of CO_2 per gallon burned.[997] As an example, a model year 2030 HDPUV with a WF of 4500 would be required to produce less than 346 gCO2/mile according to the current EPA single curve standards; due to the difference in carbon content for fuels this translates to either a required gasoline consumption of less than 3.89 gal/100miles or a required diesel consumption of less than 3.4 gal/

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[986] *Id.*

[987] 49 CFR 523.7(a).

[988] 49 CFR 523.7(b).

[989] 49 CFR 523.7(c).

[990] GM, Docket No. NHTSA–2023–0022–60686, at 7.

[991] RVIA, Docket No. NHTSA–2023–0022–51462, at 1.

[992] *See* 81 FR 73478, at 73522 (Oct. 25, 2016).

[993] RVIA also commented that motor homes are often used for extended periods in areas without access to electricity (a practice known as ''boondocking''), and that therefore requiring motor homes to be BEVs was infeasible. RVIA, NHTSA–2023–0022–51462, at 2. Again, the vehicles described by RVIA are not subject to the HDPUV standards, and the HDPUV standards themselves are performance-based and not electric-vehicle mandates.

[994] AFPM, Docket No. NHTSA–2023–0022–61911, Attachment 2, at 84.

[995] NHTSA. 2010. Factors and Considerations for Establishing a Fuel Efficiency Regulatory Program for Commercial Medium- and Heavy-Duty Vehicles. October 2010. Available at: *https://www.nhtsa.gov/sites/nhtsa.gov/files/2022-02/NHTSA_Study_Trucks.pdf* (last accessed Mar. 1, 2024).

[996] ACEEE, Docket No. NHTSA–2023–0022–60684, at 8.

[997] See Greenhouse Gases Equivalencies Calculator—Calculations and References, *https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references*, last accessed 04/18/2024.

100miles. Considering difference in carbon content between gasoline and diesel, NHTSA chose to continue to use two separate curves based on combustion (and fuel) type because the agency believes it results in a closer harmonization between the NHTSA and EPA's standards when compared in fuel efficiency space. By retaining separate CI and SI curves NHTSA's standards will not only align closer with EPA's standards, but also better balance to the agency's statutory factors for HDPUVs: cost-effectiveness and technological feasibility.

3. Attribute-Based and Defined by a Mathematical Function

For passenger cars and light trucks, EISA requires NHTSA to set CAFE standards that are ''based on 1 or more attributes related to fuel economy and express[ed]. in the form of a mathematical function.'' [998] Historically, NHTSA has based standards on vehicle footprint, and will continue to do so for model years 2027–2031. As in previous rulemakings, NHTSA defines the standards in the form of a constrained linear function that generally sets higher (more stringent) targets for smaller-footprint vehicles and lower (less stringent) targets for larger-footprint vehicles. Comments received on these aspects of the final rule are summarized and addressed in Section III.B of this preamble.

For HDPUVs, NHTSA also sets attribute-based standards defined by a mathematical function. HDPUV standards have historically been set in units of gallons per 100 miles, rather than in mpg, and the attribute for HDPUVs has historically been ''work factor,'' which is a function of a vehicle's payload capacity and towing capacity.[999] Valero argued that setting HDPUV standards in units of gallons per 100 miles was inconsistent with the statutory text, and referred to 49 U.S.C. 32902(b)(1), which states that ''average fuel economy standards'' shall be prescribed for, among other things, ''work trucks and commercial medium- and heavy-duty on-highway vehicles in accordance with subsection (k).'' Valero argued that therefore the HDPUV standards are ''fuel economy standards'' and subject to the 32902(h) prohibitions.[1000] In response, NHTSA has long interpreted ''fuel economy standards'' in the context of 49 U.S.C. 32902(k) as referring not specifically to mpg, as in the passenger car/light truck context, but instead more broadly to account as accurately as possible for MD/HD fuel efficiency. In the Phase 1 MD/HD rulemaking, NHTSA considered setting standards for HDPUVs (and other MD/HD vehicles) in mpg, but concluded that that would not be an appropriate metric given the work that MD/HD vehicles are manufactured to do.[1001] NHTSA has thus set fuel efficiency standards for HDPUVs in this manner since 2011, and further notes that 32902(h) applies by its terms to subsections (c), (f), and (g), but not (b) or (k).

While NHTSA does not interpret EISA as requiring NHTSA to set attribute-based standards defined by a mathematical function for HDPUVs, given that 49 U.S.C. 32902(b)(3)(A) refers specifically to fuel economy standards for passenger and non-passenger automobiles, NHTSA has still previously concluded that following that approach for HDPUVs is reasonable and appropriate, as long as the work performed by HDPUVs is accounted for. NHTSA therefore continues to set work-factor based gallons-per-100-miles standards for HDPUVs for model years 2030–2035.

4. Number of Model Years for Which Standards May Be Set at a Time

For passenger cars and light trucks, EISA also states that NHTSA shall ''issue regulations under this title prescribing average fuel economy standards for at least 1, but not more than 5, model years.'' [1002] For this final rule, NHTSA is establishing new CAFE standards for passenger cars and light trucks for model years 2027–2031, and to facilitate longer-term product planning by industry and in the interest of harmonization with EPA, NHTSA is also presenting augural standards for model year 2032 as representative of what levels of stringency NHTSA currently believes could be appropriate in that model year, based on the information before us today. Hyundai commented that it supported the inclusion of the augural standards for model year 2032 to the extent that they were coordinated with EPA's final GHG standards for model year 2032, and were ''representative of the actual starting point for the standards commencing in model year 2032.'' [1003] The Alliance, in contrast, argued that presenting augural standards was ''unnecessary and generally inconsistent with Congressional intent,'' and that therefore NHTSA should defer any further mention of model year 2032 standards until a future rulemaking.[1004] In response, NHTSA has coordinated with EPA to the extent possible given our statutory restrictions and we continue to emphasize that the augural standards are informational only. As explained in the NPRM, a future rulemaking consistent with all applicable law will be necessary for NHTSA to establish final CAFE standards for model year 2032 passenger cars and light trucks. While the NPRM provided information about the impacts of the standards throughout the documents without distinguishing between the standards and the augural standards in the interest of brevity, the final rule and associated documents divorced the results for the augural model year 2032 standards (including the net benefits) to be abundantly clear that they are neither final nor included as part of the agency's decision on the model year 2027–2031 standards.

The five-year statutory limit on average fuel economy standards that applies to passenger cars and light trucks does not apply to the HD pickup and van standards. NHTSA has previously stated that ''it is reasonable to assume that if Congress intended for the [MD/HD] regulatory program to be limited by the timeline prescribed in [49 U.S.C. 32902(b)(3)(B)], it would have either mentioned [MD/HD] vehicles in that subsection or included the same timeline in [49 U.S.C. 32902(k)].'' [1005] [1006] Additionally, ''in order for [49 U.S.C. 32902(b)(3)(B) to be interpreted to apply to [49 U.S.C. 32902(k)], the agency would need to give less than full weight to the . . . phrase in [49 U.S.C. 32902(b)(1)(C)] directing the Secretary to prescribe standards for 'work trucks and commercial MD or HD on-highway vehicles in accordance with Subsection (k).' Instead, this direction would need to be read to mean 'in accordance with Subsection (k) and the remainder of Subsection (b).' NHTSA believes this interpretation would be inappropriate.

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[998] 49 U.S.C. 32902(b)(3)(A) (2007).

[999] *See* 49 CFR 535.5(a)(2).

[1000] Valero, Docket No. NHTSA–2023–0022–58547, at 12.

[1001] *See* 76 FR 57106, 57112, fn. 19 (Sep. 15, 2011).

[1002] 49 U.S.C. 32902(b)(3)(B) (2007).

[1003] Hyundai, Docket No. NHTSA–2023–0022–51701, at 3.

[1004] The Alliance, Docket No. NHTSA–2023–0022–60652, at 10.

[1005] ''[W]here Congress includes particular language in one section of a statute but omits it in another section of the same Act, it is generally presumed that Congress acts intentionally and purposely in the disparate inclusion or exclusion.'' *Russello* v. *United States,* 464 U.S. 16, 23 (1983), quoting *U.S.* v. *Wong Kim Bo,* 472 F.2d 720, 722 (5th Cir. 1972). *See also Mayo* v. *Questech, Inc.,* 727 F.Supp. 1007, 1014 (E.D. Va. 1989) (conspicuous absence of provision from section where inclusion would be most logical signals Congress did not intend for it to be implied).

[1006] 76 FR 57106, 57131 (Sep. 15, 2011).

Interpreting 'in accordance with Subsection (k)' to mean something indistinct from 'in accordance of this Subsection' goes against the canon that statutes should not be interpreted in a way that 'render[s] language superfluous.' *Dobrova* v. *Holder,* 607 F.3d 297, 302 (2d Cir. 2010), quoting *Mendez* v. *Holder,* 566 F.3d 316, 321–22 (2d Cir. 2009).'' [1007] As a result, the standards previously set remain in effect indefinitely at the levels required in the last model year, until amended by a future rulemaking action.

5. Maximum Feasible Standards

As discussed above, EPCA requires NHTSA to consider four factors in determining what levels of CAFE standards (for passenger cars and light trucks) would be maximum feasible—technological feasibility, economic practicability, the effect of other motor vehicle standards of the Government on fuel economy, and the need of the United States to conserve energy. For determining what levels of fuel efficiency standards (for HDPUVs) would be maximum feasible, EISA requires NHTSA to consider three factors—whether a given fuel efficiency standard would be appropriate, cost-effective, and technologically feasible. NHTSA presents in the sections below its understanding of the meanings of all those factors in their respective decision-making contexts.

a. Passenger Cars and Light Trucks

(1) Technological Feasibility

''Technological feasibility'' refers to whether a particular method of improving fuel economy is available for deployment in commercial application in the model year for which a standard is being established. Thus, NHTSA is not limited in determining the level of new standards to technology that is already being applied commercially at the time of the rulemaking. For this final rule, NHTSA has considered a wide range of technologies that improve fuel economy, while considering the need to account for which technologies have already been applied to which vehicle mode/configuration, as well as the need to estimate, realistically, the cost and fuel economy impacts of each technology as applied to different vehicle models/configurations. MEMA commented that it ''appreciated NHTSA's openness to using different constellations of powertrains (BEV, PHEV, mild hybrid, ICE, FCEV, etc.) to comply with the standards.'' [1008] NHTSA thanks MEMA, and continues to believe that the range of technologies considered, as well as how the technologies are defined for purposes of the analysis, is reasonable, based on our technical expertise, our independent research, and our interactions with stakeholders. NHTSA has not, however, attempted to account for every technology that might conceivably be applied to improve fuel economy, nor does NHTSA believe it is necessary to do so, given that many technologies address fuel economy in similar ways.[1009]

Several commenters focused on the technological feasibility of electrifying vehicle fleets. Jaguar commented that ''At present, there are increasingly limited opportunities with regards to technologies that will meet the incredibly challenging standards set. Soon, it will only be possible to meet these targets with increased BEV sales.'' [1010] Volkswagen commented that there may not be enough American-sourced batteries to meet both Inflation Reduction Act requirements and the proposed standards, that those limitations would prevent industry from manufacturing more than a certain number of BEVs per year, and that therefore the proposed standards were beyond technologically feasible and civil penalty payment would be unavoidable.[1011] AVE expressed concern about whether supply chains would be fully developed to support compliance.[1012] CFDC et al., a group of corn-based ethanol producers' organizations, argued that ''shockingly high numbers'' of electric vehicles would be required by the proposed standards, and that therefore the proposed standards were infeasible and unlawful because they could not be met without electric vehicles.[1013] The commenter further argued that ''the proposal systematically neglects the fact that there are simply not enough minerals, particularly lithium, available to sustain global electric vehicle growth,'' and that ''this is an insuperable obstacle [that makes] NHTSA's proposal not technologically feasible.'' [1014] RFA et al., another group of corn-based ethanol producers' organizations, commented that NHTSA had not adequately considered the technological feasibility of the regulatory reference baseline (*i.e.,* the amount of electrification assumed in response to State ZEV programs and assumed market demand), and that NHTSA's analysis of technological feasibility now needed to include consideration of critical mineral availability and BEV charging infrastructure.[1015] The Alliance commented that when it ran the CAFE model with BEVs removed from the analysis entirely and with no option for paying civil penalties, many fleets appeared unable to meet the proposed standards, which meant that the proposed standards were not technologically feasible.[1016] AFPM offered similar comments.[1017]

In response, NHTSA clarifies, again, that CAFE standards are performance-based standards, not technology mandates, and that NHTSA cannot set standards that *require* BEVs because NHTSA is statutorily prohibited from considering BEV fuel economy in determining maximum feasible CAFE standards. Commenters objecting to electrification shown in NHTSA's analysis are looking at what is assumed in the *reference baseline* levels, not what is required to meet NHTSA's final standards being promulgated in this rulemaking. As Table VI1 shows, the technology penetration rates for the various alternatives do not result in further penetration of BEVs in response to the action alternatives, although they do illustrate a potential compliance path for industry that would rely on somewhat higher numbers of SHEVs.

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[1007] *Id.*

[1008] MEMA, Docket No. NHTSA–2023–0022–59204–A1, at 3.

[1009] For example, NHTSA has not considered high-speed flywheels as potential energy storage devices for hybrid vehicles; while such flywheels have been demonstrated in the laboratory and even tested in concept vehicles, commercially available hybrid vehicles currently known to NHTSA use chemical batteries as energy storage devices, and the agency has considered a range of hybrid vehicle technologies that do so.

[1010] Jaguar, Docket No. NHTSA–2023–0022–57296, at 3.

[1011] Volkswagen, Docket No. NHTSA–2023–0022–58702, at 5.

[1012] AVE, Docket No. NHTSA–2023–0022–60213, at 3–4.

[1013] CFDC *et al.,* Docket No. NHTSA–2023–0022–62242, at 10.

[1014] *Id.* at 16.

[1015] RFA *et al.* 2, Docket No. NHTSA–2023–0022–57625, at 16–18.

[1016] The Alliance, Docket No. NHTSA–2023–0022–60652, Appendix B, at 8–9.

[1017] AFPM, Docket No. NHTSA–2023–0022–61911, Attachment 2, at 37.

Table VI-1: Passenger Car and Light Truck Combined Fleet Technology Penetration Rates and Penetration Rate Changes by Model Year (Percent)[1018]

	2027	2028	2029	2030	2031
Advanced Gasoline Engines[1019]					
No Action	17.9	16.6	15.1	14.6	14.1
PC2LT002	-0.8	-2.0	-3.2	-3.4	-4.1
PC1LT3	-2.2	-3.4	-4.7	-5.4	-5.9
PC2LT4	-2.7	-3.9	-5.3	-6.5	-7.9
PC3LT5	-2.9	-4.1	-5.7	-7.1	-9.1
PC6LT8	-2.9	-4.1	-6.2	-8.2	-10.3
SHEV					
No Action	22.3	22.8	24.4	24.0	23.3
PC2LT002	+0.3	+2.5	+4.8	+6.0	+5.0
PC1LT3	+2.6	+7.0	+10.7	+12.8	+11.7
PC2LT4	+4.1	+9.6	+13.6	+17.5	+17.4
PC3LT5	+4.3	+10.0	+15.0	+20.1	+21.9
PC6LT8	+4.8	+14.3	+21.2	+28.2	+31.1
PHEV					
No Action	1.9	1.9	1.9	1.9	1.8
PC2LT002	+1.9	+1.9	+1.9	+1.8	+3.9
PC1LT3	+1.0	+1.0	+1.0	+1.0	+3.1
PC2LT4	+1.0	+1.0	+1.0	+1.0	+3.1
PC3LT5	+1.0	+1.0	+1.0	+1.0	+3.1
PC6LT8	+1.0	+1.0	+1.0	+1.0	+3.1
BEV[1020]					
No Action	20.5	21.5	22.8	25.1	28.1
PC2LT002	0.0	0.0	0.0	0.0	0.0
PC1LT3	0.0	0.0	0.0	0.0	0.0
PC2LT4	0.0	0.0	0.0	0.0	0.0
PC3LT5	0.0	0.0	0.0	0.0	0.0
PC6LT8	0.0	0.0	0.0	0.0	0.0

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As to whether NHTSA is required to prove that the reference baseline as well as the CAFE standards are technologically feasible—a point also inherent in the Alliance comments, because the BEVs that the Alliance removed from its analysis were nearly all in the reference baseline—NHTSA disagrees that this is the agency's obligation under EPCA/EISA. Section IV above discusses the various considerations that inform the reference baselines. NHTSA has determined it is reasonable to assume that certain technologies will appear in the reference baseline, regardless of any action by NHTSA, in response to cost-effectiveness/market demand (as would occur if battery prices fall as currently assumed in our analysis, for example). Similarly, if certain technologies appear in the reference baseline because manufacturers have said they would plan to meet State regulations, then either the manufacturers have concluded that doing so is feasible (else they would not plan to do so), and/or the State(s) involved have made and are responsible for any determinations about feasibility. Nothing in EPCA/EISA compels NHTSA to be responsible for proving the feasibility of things which are beyond our authority, like State regulations or development of charging infrastructure or permitting of critical minerals production sites, and which involve consideration of technologies which NHTSA itself is prohibited from

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[1018] The values in the table report fleet-wide technology penetration rates in the No-Action Alternative and differences from this baseline in the action alternatives.

[1019] Advanced Gasoline Engines includes SGDI, DEAC, and TURBO0.

[1020] Minor technology penetration differences exist due to rounding and changes in fleet size and regulaory class composition. Changes less than 0.1% were rounded to zero for this table.

considering. Just as it is not NHTSA's authority or responsibility to determine whether State programs *are* feasible, so it is not NHTSA's responsibility to determine whether State programs *are not* feasible. State programs are developed under State legal authority, and their feasibility is a matter for the State(s) and vehicle manufacturers (and other interested parties) to discuss. Nonetheless, NHTSA continues to believe that it is reasonably foreseeable that manufacturers will at least plan to meet legally binding State regulations, and thus to reflect that intent in our regulatory reference baseline so that we may best reflect the world as it would look in the absence of further regulatory action by NHTSA.

Reviewing Table VI–1 above, our analysis of the final rule illustrates a technology path in which manufacturers might modestly increase strong hybrid-based technologies beyond reference baseline levels. CTLCV commented that the technology exists to meet the standards, but that the auto industry ''must be required to provide the most efficient versions of gas-powered vehicles possible and not stand in the way of our transition to zero-emission vehicles.''[1021] The Joint NGOs commented that NHTSA's proposed standards were below maximum feasible levels because they do not represent future possible improvements that manufacturers could conceivably make to ICE vehicles.[1022] The Joint NGOs cited the 2022 EPA Trends Report as indicating that various manufacturers had ''underutilized'' technologies ''such as turbocharged engines, continuously variable transmission and cylinder deactivation.''[1023] The Joint NGOs next cited an ICCT study suggesting that further ''continual'' improvements to cylinder deactivation, high compression Atkinson cycle engines, light weighting, and mild hybridization'' could increase the fuel economy benefits of those technologies.[1024] The Joint NGOs then suggested that manufacturers could change the mix of vehicles they produced in a given model year so that only the ''cleanest powertrain'' was sold for each vehicle model.[1025] The Joint NGOs later stated that NHTSA's analysis was based on ''what manufacturers 'will,' 'would,' or are 'likely to' do—rather than what manufacturers 'can' or 'could' do.'' The Joint NGOs argued that ''many of these assumptions about what 'would' happen are also based on a review of historical practice, rather than a forward-looking assessment of possibility.''[1026] The States and Cities also argued that all of the alternatives in the proposal were technologically feasible because they could be met with varying amounts of mass reduction and strong hybrids, technologies that certainly exist and are available for deployment.[1027] This commenter further argued that mass reduction was highly effective and that NHTSA should use its authority to encourage more mass reduction.[1028] Nissan, in contrast, expressed concern that the proposal would ''divert significant resources towards further technological development of ICE vehicles, rather than allowing manufacturers to focus on fleet electrification goals.''[1029]

In response, while NHTSA sets performance-based standards rather than specifying which technologies should be used, NHTSA is mindful that industry is in the early to mid-stages of a major technological transition. *NHTSA* may not consider the fuel economy of BEVs when setting standards, but industry has made it extremely clear that it is committed to the transition to electric vehicles. The contrast between the comments from NRDC and the States and Cities, calling on NHTSA to somehow specifically require ongoing ICE vehicle improvements, and from Nissan, arguing that NHTSA must *not* require further ICE vehicle improvements, highlights this issue. NHTSA agrees that the technological feasibility factor allows NHTSA to set standards that force the development and application of new fuel-efficient technologies but notes this factor does not require NHTSA to do so.[1030] In the 2012 final rule, NHTSA stated that ''[i]t is important to remember that technological feasibility must also be balanced with the other of the four statutory factors. Thus, while 'technology feasibility' can drive standards higher by assuming the use of technologies that are not yet commercial, 'maximum feasible' is also defined in terms of economic practicability, for example, which might caution the agency against basing standards (even fairly distant standards) entirely on such technologies.''[1031] NHTSA further stated that ''as the 'maximum feasible' balancing may vary depending on the circumstances at hand for the model year in which the standards are set, the extent to which technological feasibility is simply met or plays a more dynamic role may also shift.''[1032] With performance-based standards, NHTSA cannot mandate the mix of technologies that manufacturers will use to achieve compliance, so it is not within NHTSA's power to specifically require any particular type of ICE vehicle improvements, as NRDC and the States and Cities suggest and as Nissan fears. In determining maximum feasible CAFE standards, however, NHTSA can do its best to balance the concerns raised by all parties, as they fall under the various statutory factors committed to NHTSA's discretion. Whether these concerns are properly understood as ones of ''technological feasibility'' is increasingly murky as the technology transition (that NHTSA cannot consider directly) proceeds. NHTSA has also grappled with whether the ''available for deployment in commercial application'' language of our historical interpretation of technological feasibility is appropriately read as ''available for deployment in the world'' or ''available for deployment given the restrictions of 32902(h).'' The Heritage Foundation commented that ''There is no doubt that EPCA is referring to'' ICE vehicles in describing technological feasibility, because EPCA defines ''fuel'' as referring to gasoline or diesel fuels and electricity as an ''alternative fuel,'' and NHTSA is prohibited from considering alternative fueled vehicles in determining maximum feasible CAFE standards.[1033] Hyundai argued that the proposed PC2LT4 standards were not technologically feasible, because (1) the regulatory reference baseline included BEVs, and (2) DOE's changes to the PEF value and NHTSA's proposal to reduce available AC/OC flexibilities made any standards harder to meet.[1034] NHTSA agrees that it cannot consider BEV fuel economy in determining maximum feasible standards, but NHTSA reiterates that the technological transition that NHTSA is prohibited from considering in setting standards complicates the historical approach to the statutory factors. It may well be that in light of this transition, a better interpretation is

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[1021] CTLCV, Docket No. NHTSA–2023–0022–29018, at 2.

[1022] Joint NGOs, Docket No. NHTSA–2023–0022–61944, NGO Comment Appendix, at 6.

[1023] *Id.* at 6–7.

[1024] *Id.*

[1025] *Id.*

[1026] *Id.* at 51–52.

[1027] States and Cities, Docket No. NHTSA–2023–0022–61904, Attachment 2, at 28.

[1028] *Id.*

[1029] Nissan, Docket No. NHTSA–2023–0022–60696, at 3.

[1030] *See* 77 FR 63015 (Oct. 12, 2012).

[1031] *Id.*

[1032] *Id.*

[1033] Heritage Foundation, Docket No. NHTSA–2023–0022–61952, at 4.

[1034] Hyundai, Docket No. NHTSA–2023–0022–51701, at 5–6.

for technological feasibility to be specifically limited to the technologies that NHTSA is permitted to consider.

Nevertheless, in the overall balancing of factors for determining maximum feasible, the above interpretive question may not matter, because it is clear that the very high cost of the most stringent alternatives likely puts them out of range of economic practicability, especially if manufacturers appear in NHTSA's analysis to be broadly resorting to payment of civil penalties rather than complying through technology application. Although some companies historically have chosen to pay civil penalties as a more cost-effective option than compliance, which NHTSA has not seen as an indication of infeasibility previously, the levels of widespread penalty payment rather than compliance projected in this analysis is novel. Further, penalty payment could detract from fuel economy during these particular model years, where manufacturers are devoting significant resources to a broader transition to electrification. Effectively, given the statutory constraints under which NHTSA must operate, and constraining technology deployment to what is feasible under expected redesign cycles, NHTSA does not see a technology path to reach the higher fuel economy levels that would be required by the more stringent alternatives, in the time frame of the rulemaking. Moreover, even if technological feasibility were not a barrier, that does not mean that requiring that technology to be added would be economically practicable under these specific circumstances.

IPI commented that NHTSA's inclusion in the NPRM of tables showing technology penetration rates under the ''standard setting'' analysis belied NHTSA's suggestion in the NPRM that there did not appear to be a technology path to reach the higher fuel economy levels that would be required by the more stringent alternatives.[1035] IPI suggested that either NHTSA must believe the more stringent alternatives to be impossible to meet in the rulemaking time frame, or that NHTSA was ''collapsing'' the technological feasibility factor into the economic practicability factor by considering cost under the heading of technological feasibility.[1036]

In response, within the context of the constrained analysis which NHTSA must consider by statute, NHTSA does find that there is no technology path for the majority of manufacturers to meet the most stringent CAFE alternatives, considering expected redesign cycles, without shortfalling and resorting to penalties. Even setting aside that some manufacturers have historically chosen to pay penalties rather than applying technology as an economic decision, NHTSA's final rule (constrained) analysis illustrates that a number of manufacturers do not have enough opportunities to redesign enough vehicles during the rulemaking time frame in order to achieve the levels estimated to be required by the more stringent alternatives.

Figure VI–2 through Figure VI–4 present several manufacturer-fleet combinations that clearly illustrate these limits in NHTSA's statutorily constrained analysis. The figures present fleet powertrain distribution along with vehicle redesign cycles.[1037] Each bar in the figure represents total manufacturer-fleet sales in a given model year, and bars are shaded to indicate the composition of sales by powertrain. Any portion of the bar with overlayed hashed lines denotes the portion of the manufacturer's fleet that is not eligible for redesign (*i.e.,* cannot change powertrain) in that model year, often due to recent redesigns and the need to adhere to the redesign cycle to avoid imposing costs for which NHTSA does not currently account.[1038] The left and right panels of the figure present results for the least and most stringent action alternatives, respectively, for comparison.

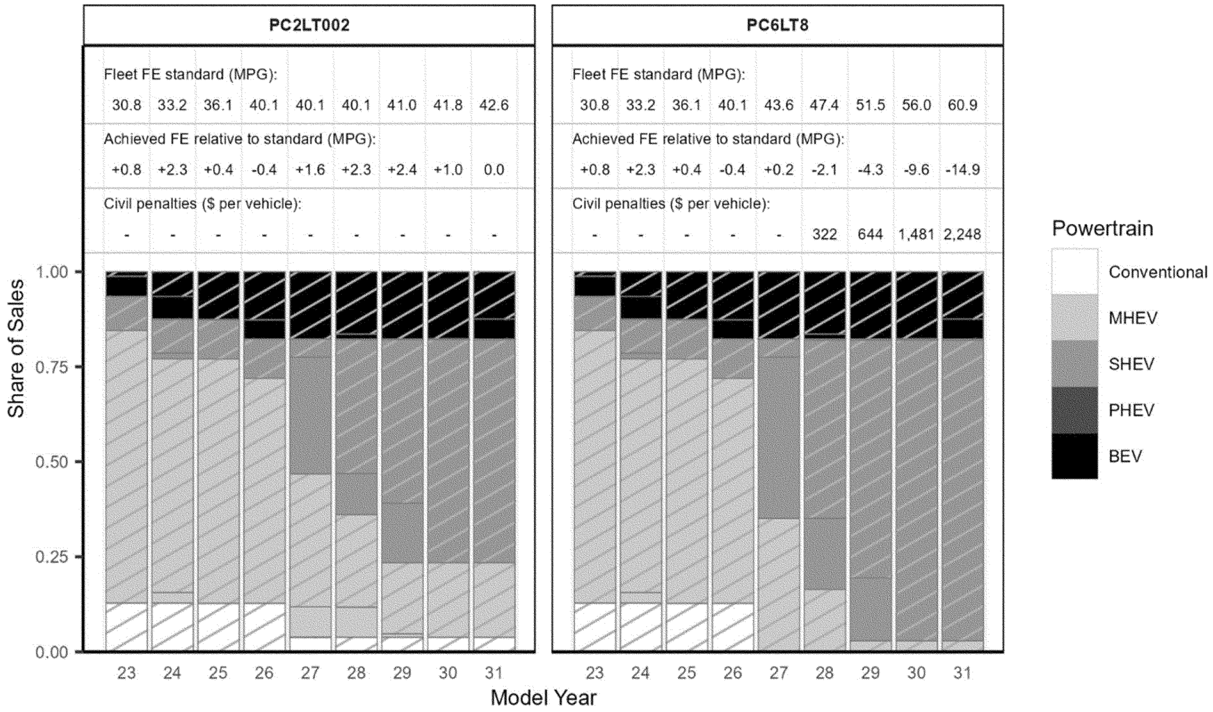
[1035] IPI, Docket No. NHTSA–2023–0022–60485, at 9.

[1036] *Id.*

[1037] Manufacturers also apply non-powertrain technology to improve vehicle fuel economy, and likely do so in these examples, but these plots are limited to powertrain conversion and eligibility to simplify the illustration. Note also that any increase in BEV share in model year 2027 and beyond is the result of ZEV compliance, as BEV conversion is constrained during standard-setting years.

[1038] See TSD Chapter 2.6 for more information on refresh and redesign assumptions.

Figure VI-2: Powertrain Compliance Pathway Illustration, Ford, Light Truck



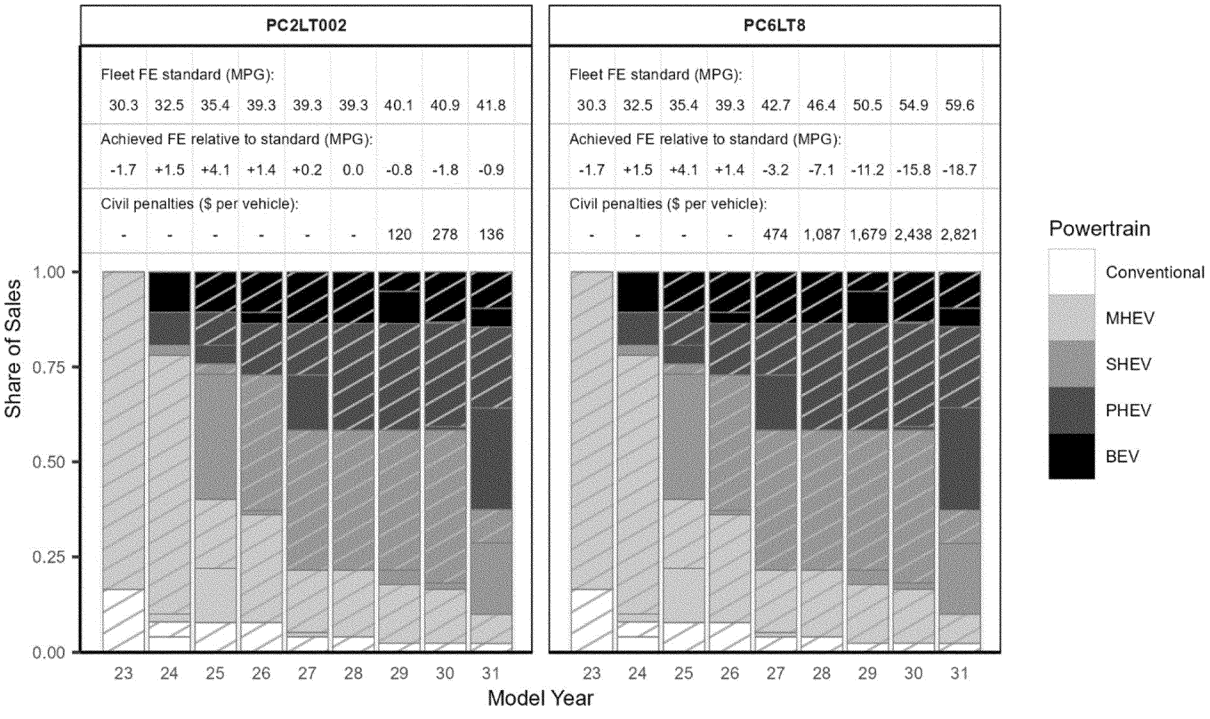
Hashed components are ineligible for powertrain modification.

Figure VI–2 displays these results for Ford's light truck fleet. Under PC2LT002 (left panel), Ford's fleet complies with the standards in all model years, as shown in the row ''Achieved FE relative to standard,'' which has all results either positive or zero (meaning that the fleet exactly complies with Ford's estimated applicable standard). This occurs because the model converts a large part of the Ford light trucks eligible for redesign to SHEVs in model year 2027, represented by the large, un-hashed dark gray segment in the center of the model year 2027 bar. It continues to convert eligible MHEVs to SHEVs in model year 2028 and model year 2029. Under PC6LT8 (right panel), Ford converts all eligible vehicles to SHEVs in model years 2027, 2028, and 2029. Even with this technology application, Ford's achieved fuel economy levels do not meet the alternative's estimated standards (note the negative values in the row ''Achieved FE relative to standard,'') and Ford is therefore assumed to pay civil penalties for model years 2028 and beyond. Under all alternatives, Ford has no light trucks eligible for redesign in model year 2030, and the only vehicles whose redesign schedule makes them eligible in model year 2031 are BEVs, which represent the end of the powertrain pathway and have no other technology that may be applied.[1039] According to the statutorily-constrained analysis that NHTSA considers for determining maximum feasible standards, Ford simply cannot comply with the PC6LT8 light truck standards beginning in model year 2028, because it has redesigned all the light trucks that it can (consistent with its redesign schedule) and is out of technology moves.

Other manufacturers encounter similar constraints at higher stringency levels and across fleets. As shown in Figure VI–3, the model converts nearly all eligible portions of GM's light truck fleet to PHEVs, but GM still encounters compliance constraints. These constraints are marginal under PC2LT002, but under PC6LT8, GM is unable to comply beginning in model year 2027, with shortfalls exceeding 3 MPG.

[1039] At the time of the analysis, FCV technology is projected to make up a non-substantive percentatge of the fleet, and FCV is therefore not shown in the graphics, *See* technology penetration rates in FRIA Databook Appendices.

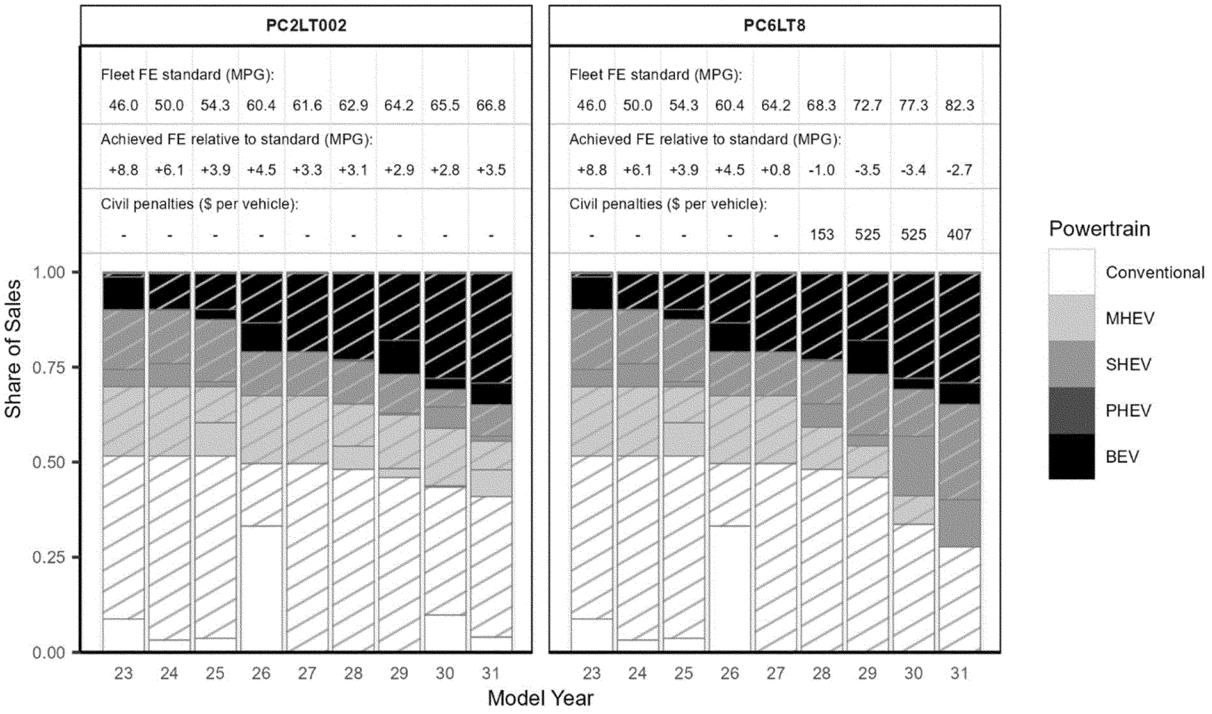
Figure VI-3: Powertrain Compliance Pathway Illustration, GM, Light Truck



Hashed components are ineligible for powertrain modification.

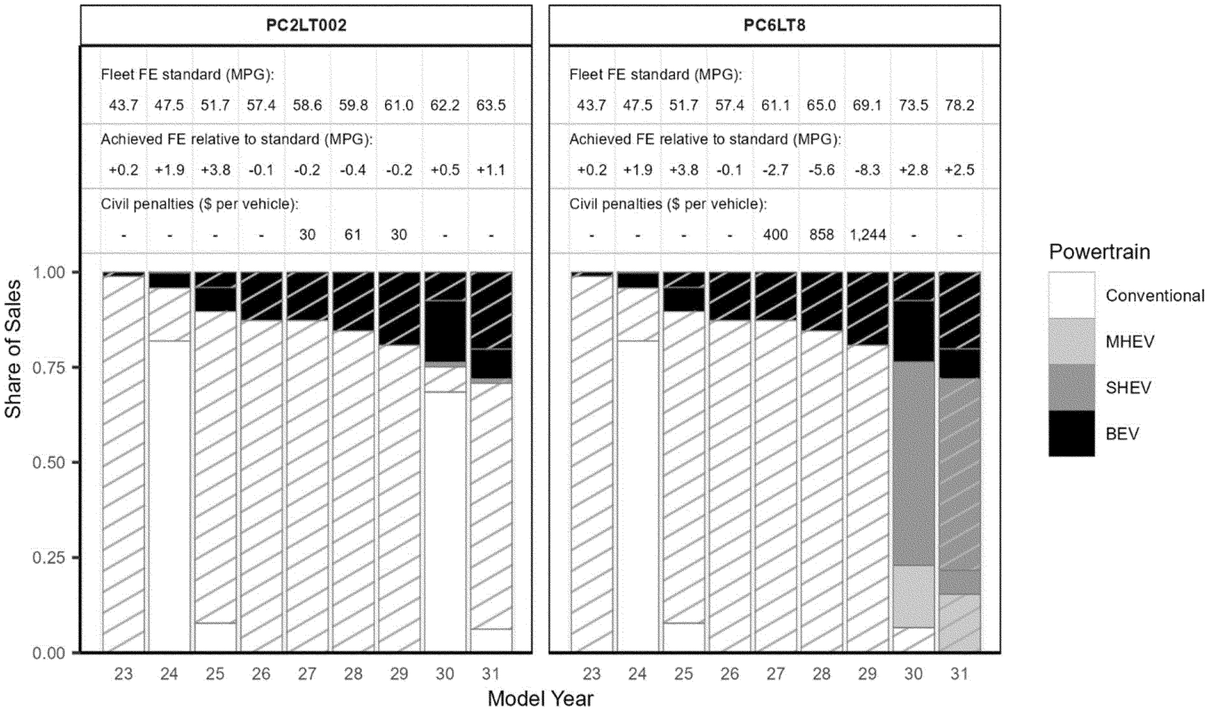
Figure VI–4 and Figure VI–5 show Toyota's import and domestic passenger car fleet, respectively. Under PC2LT002, Toyota's import passenger car fleet exceeds the applicable standard for all years, but in contrast Toyota's domestic passenger car fleet falls slightly short during model years 2027–2029. As in the other examples, this occurs due to the lack of powertrains eligible for redesign during those years. This phenomenon is even more pronounced and affects both Toyota's import and domestic passenger car fleets, under PC6LT8. Both of Toyota's passenger car fleets develop shortfalls but only the domestic fleet is able to eliminate the shortfall in the rulemaking time frame when redesigns are available in model year 2030.

Figure VI-4: Powertrain Compliance Pathway Illustration, Toyota, Imported Car



Hashed components are ineligible for powertrain modification.

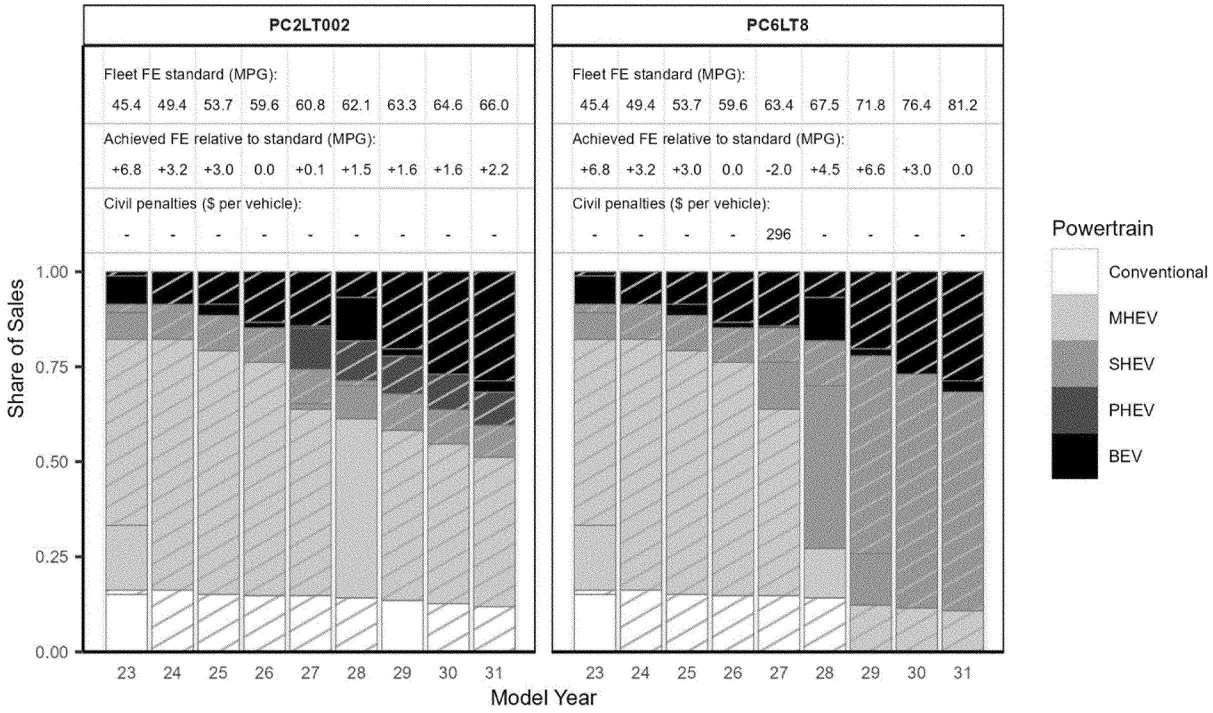
Figure VI-5: Powertrain Compliance Pathway Illustration, Toyota, Domestic Car



Hashed components are ineligible for powertrain modification.

Figure VI–6 shows Honda's domestic passenger car fleet CAFE performance.[1040] Under PC2LT002, the passenger car fleet complies with the standard across all years, achieving a 0.1 mpg overcompliance in model year 2027 and slowly increasing to a 2.2 mpg overcompliance by the end of the standard setting years. Under PC6LT8, Honda is unable to meet the standard for model year 2027 but reaches compliance by model year 2028 and maintains it through the standard-setting years. However, it is worth noting that the fleet drops from a 6.6 mpg overcompliance in model year 2029 to zero overcompliance in model year 2031, after converting over 75 percent of their fleet to advanced powertrain technologies, and Honda is the only non-BEV manufacturer to achieve consistent compliance under the highest stringency.

Figure VI-6: Powertrain Compliance Pathway Illustration, Honda, Domestic Car



Hashed components are ineligible for powertrain modification.

[1040] Only Honda's Domestic Car fleet is shown here; Honda's import car fleet makes up approxametly 1 percent of their U.S. sales volume.

NHTSA conducted similar analysis for every manufacturer-fleet combination and found similar patterns and constraints on compliance. Results for manufacturers that make up the top 80 percent of fleet sales in model year 2031 are included in Table VI–2 and Table VI–3.

In the light truck fleet, nearly all vehicles are either ineligible for redesign or reach the end of their powertrain compliance pathways under PC6LT8, with the majority of manufacturers not achieving compliance, some falling short by as much as 18.7 mpg. Under PC2LT002, most manufacturers achieve the standard and overcomply somewhat, with only two manufacturers showing any shortfalls. And in all cases shown, representing 80 percent of all light truck sales volume, shortfalls are 1.8 mpg or less under PC2LT002.

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Table VI-2: Manufacturer Fleet Status Summary, Light Truck

	PC2LT002					PC6LT8				
	2027	2028	2029	2030	2031	2027	2028	2029	2030	2031
Ford										
Share eligible	12%	8%	1%	0%	0%	0%	0%	0%	0%	0%
Compliance position	+1.6	+2.3	+2.4	+1.0	0.0	+0.2	-2.1	-4.3	-9.6	-14.9
Civil penalties	-	-	-	-	-	-	322	644	1,481	2,248
Toyota										
Share eligible	0%	3%	2%	3%	13%	0%	0%	0%	0%	0%
Compliance position	+1.5	+2.4	+2.6	+2.8	+3.7	-2.2	-4.1	-6.8	-10.1	-11.2
Civil penalties	-	-	-	-	-	326	628	1,019	1,559	1,690
GM										
Share eligible	1%	0%	0%	0%	0%	1%	0%	0%	0%	0%
Compliance position	+0.2	0.0	-0.8	-1.8	-0.9	-3.2	-7.1	-11.2	-15.8	-18.7
Civil penalties	-	-	120	278	136	474	1,087	1,679	2,438	2,821
Stellantis										
Share eligible	13%	0%	7%	0%	0%	0%	0%	0%	0%	0%
Compliance position	+0.5	+0.1	+0.7	-0.1	-0.1	-1.6	-5.9	-8.0	-12.6	-16.8
Civil penalties	-	-	-	15	15	237	904	1,199	1,944	2,535
Honda										
Share eligible	0%	10%	6%	19%	0%	0%	0%	0%	0%	0%
Compliance position	+1.8	+3.0	+3.0	+3.0	+3.5	-1.5	-3.0	-5.6	-6.2	-10.2
Civil penalties	-	-	-	-	-	222	459	839	957	1,539
Subaru										
Share eligible	0%	19%	37%	24%	0%	0%	0%	17%	0%	0%
Compliance position	+2.7	+4.4	+5.0	+5.7	+6.9	-1.5	-0.9	+1.9	+4.2	+0.2
Civil penalties	-	-	-	-	-	222	138	-	-	-
Nissan										
Share eligible	0%	45%	0%	21%	0%	0%	0%	0%	0%	0%
Compliance position	-2.1	+0.3	+0.1	+1.0	+0.8	-5.9	-4.0	-7.7	-5.9	-10.7
Civil penalties	44	-	-	-	-	608	613	1,154	910	1,614

Share eligible: Share of manufacturer fleet model year sales eligible for redesign that are conventional or MHEV powertrain.

Compliance position: Manufacturer fleet achieved fuel economy relative to standard.

Civil penalties: Average manufacturer fleet civil penalties in dollars per vehicle.

All manufacturers shown, representing 80 percent of all passenger car sales volume, generally comply with fleet fuel economy levels in the passenger car fleet for the preferred alternative. Some manufacturers do show one or two years of shortfalls in the rulemaking time frame, resulting from redesign rate constraints, indicated by a lack of share eligibility. At high stringency levels, such as PC6LT8, the rate of stringency increase coupled with limited share eligibility makes compliance for the majority of the fleet untenable in NHTSA's statutorily constrained analysis.

Table VI-3: Manufacturer Fleet Status Summary, Passenger Car[1041]

	PC2LT002					PC6LT8				
	2027	2028	2029	2030	2031	2027	2028	2029	2030	2031
Toyota										
Share eligible	0%	5%	2%	25%	10%	0%	0%	0%	4%	0%
Compliance position	+2.3	+2.1	+2.0	+2.2	+2.9	-0.2	-2.3	-4.9	-1.8	-1.3
Civil penalties	7	15	7	-	-	100	329	704	394	306
Honda										
Share eligible	0%	47%	0%	0%	0%	0%	13%	0%	0%	0%
Compliance position	+0.1	+1.5	+1.6	+1.6	+2.2	-2.0	+4.5	+6.6	+3.0	0.0
Civil penalties	-	-	-	-	-	296	-	-	-	-
Nissan										
Share eligible	0%	0%	0%	10%	0%	0%	0%	0%	0%	0%
Compliance position	+3.2	+1.0	-1.1	+0.3	+1.0	+0.6	-2.0	-7.2	-8.0	-6.6
Civil penalties	-	78	271	-	-	139	676	1,182	1,191	990
Hyundai										
Share eligible	0%	0%	17%	0%	5%	0%	0%	0%	0%	0%
Compliance position	+4.8	+2.4	+2.9	+1.3	+2.8	+4.0	-1.2	-0.7	-5.6	-6.7
Civil penalties	-	-	-	-	-	-	415	334	1,046	1,197
Tesla										
Share eligible	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Compliance position	+325	+183	+117	+78.9	+77.6	+323	+178	+109	+68.2	+63.6
Civil penalties	-	-	-	-	-	-	-	-	-	-
GM										
Share eligible	0%	0%	0%	0%	7%	0%	0%	0%	0%	0%
Compliance position	+1.7	-1.0	+1.9	+0.2	+1.6	-0.9	-6.4	-6.5	-11.6	-11.7
Civil penalties	8	152	38	-	-	142	992	980	1,788	1,705
Kia										
Share eligible	0%	0%	0%	14%	2%	0%	0%	0%	0%	0%
Compliance position	-0.4	-0.4	+0.6	+1.0	+1.8	-3.0	-5.7	-4.9	-1.0	+1.8
Civil penalties	59	89	91	-	-	448	884	1,047	445	-
VWA										
Share eligible	0%	18%	0%	0%	8%	0%	0%	0%	0%	0%
Compliance position	+1.8	+5.4	+1.7	-0.1	+1.3	-0.9	+4.0	-2.9	-8.4	-9.8
Civil penalties	55	-	14	215	-	427	-	613	1,405	1,541

Share eligible: Share of manufacturer fleet model year sales eligible for redesign that are conventional or MHEV powertrain.

Compliance position: Manufacturer fleet achieved fuel economy relative to standard.

Civil penalties: Average manufacturer fleet civil penalties in dollars per vehicle.

[1041] The passenger car fleet contains both domestic and imported car fleets. Shortfalls can occur in one fleet while the overall passenger car fleet remains in compliance. This could result in estimiated civil penalties with a positive compliance positon, as in the case of Nissan in model year 2028.

The compliance illustrations in the figures and tables above demonstrate the challenge that higher stringencies pose, especially within the constrained modeling framework required by statute. Historically, in the constrained analysis, the higher levels of electrification that could be considered under the statute (SHEV and PHEV in charge sustaining mode) in addition to advanced engine modifications (turbocharging and HCR) easily provided the effectiveness levels needed to raise the manufacturers' fleet fuel economy when applied at the rates governed by refresh and redesign schedules.[1042] In past analyses, the cost of converting the vehicles to the new technologies was the limiting factor. However, the remaining percentages of fleets that can be modified consistent with redesign and refresh cycles, coupled with the limits of total fuel efficiency improvement possible (considering only statutorily-allowed technologies), now limits what is achievable by the manufacturers in the time frame of the rule. Regardless of the technology cost, or application of penalties, higher levels of fuel economy improvement are simply not achieved under the higher stringency alternatives, often because manufacturers have no opportunity to make the improvement and the statutorily-available technologies will not get them to where they would need to be.

For purposes of model years 2027–2031, NHTSA concludes that sufficient technology and timely opportunities to apply that technology exist to meet the final standards. Moreover, as Table VI–1 above shows, NHTSA's analysis demonstrates a technology path to meet the standards that does not involve application of BEVs, FCEVs, or other prohibited technologies. NHTSA therefore believes that the final standards are technologically feasible.

As discussed above, NHTSA also conducted a ''No ZEV alternative baseline'' analysis. Technology penetration rates and manufacturer compliance status results are somewhat different under that analysis, as might be foreseeable.

[1042] *See, e.g.,* 87 FR 25710 (May 2, 2022).

Table VI-4: Passenger Car and Light Truck Combined Fleet Technology Penetration Rates and Penetration Rate Changes by Model Year (Percent) Under No ZEV Alternative Baseline[1043]

	2027	2028	2029	2030	2031
Advanced Gasoline Engines[1044]					
No Action	16.9	15.8	14.5	14.3	14.3
PC2LT002	-1.0	-2.2	-4.3	-6.3	-8.2
PC1LT3	-1.6	-2.8	-4.9	-6.7	-8.3
PC2LT4	-1.7	-2.9	-4.9	-6.9	-9.1
PC3LT5	-1.7	-2.9	-5.0	-7.2	-9.6
PC6LT8	-1.6	-2.9	-5.1	-7.4	-9.8
SHEV					
No Action	23.4	24.2	26.2	26.7	26.8
PC2LT002	+1.0	+4.5	+9.5	+15.9	+17.9
PC1LT3	+2.7	+9.3	+14.4	+21.2	+23.4
PC2LT4	+2.9	+10.8	+17.9	+25.9	+29.0
PC3LT5	+3.2	+11.4	+19.5	+27.9	+32.2
PC6LT8	+3.4	+14.3	+22.8	+31.3	+35.9
PHEV					
No Action	2.9	2.9	2.9	2.9	2.9
PC2LT002	+0.8	+0.9	+1.2	+1.2	+3.3
PC1LT3	+0.7	+0.7	+0.7	+0.7	+2.8
PC2LT4	+0.7	+0.7	+0.8	+0.9	+2.9
PC3LT5	+0.7	+0.7	+0.8	+0.8	+2.9
PC6LT8	+0.7	+0.8	+0.8	+0.8	+2.9
BEV[1045]					
No Action	19.1	19.0	19.0	19.0	19.0
PC2LT002	0.0	0.0	0.0	0.0	0.0
PC1LT3	0.0	0.0	0.0	0.0	0.0
PC2LT4	0.0	0.0	0.0	0.0	0.0
PC3LT5	0.0	0.0	0.0	0.0	0.0
PC6LT8	0.0	0.0	0.0	0.0	0.0

[1043] The values in the table report fleet-wide technology penetration rates in the No-Action Alternative and differences from this baseline in the action alternatives.

[1044] Advanced Gasoline Engines includes SGDI, DEAC, and TURBO0.

[1045] Minor technology penetration differences exist due to rounding and changes in fleet size and regulaory class composition. Changes less than 0.1% were rounded to zero for this table.

Comparing to the reference case baseline analysis results in Table VI–1, under the No ZEV alternative baseline analysis, BEV rates in the baseline go down in every model year (and remain at 0 percent for all action alternatives due to statutory constraints implemented in the model); SHEV rates increase by several percentage points; PHEV rates go up by about 1 percent; and advanced gasoline engine rates remain roughly the same in the baseline but drop several percentage points in the action alternatives. These trends hold across action alternatives.

Table VI-5: Manufacturer Fleet Status Summary Under No ZEV Alternative Baseline, Light Truck

	PC2LT002					PC6LT8				
	2027	2028	2029	2030	2031	2027	2028	2029	2030	2031
Ford										
Share eligible	9%	8%	1%	0%	0%	0%	0%	0%	0%	0%
Compliance position	+2.0	+2.6	+2.8	+1.3	+0.3	+0.3	-2.0	-4.2	-9.6	-14.9
Civil penalties	-	-	-	-	-	-	306	629	1,481	2,248
Toyota										
Share eligible	0%	3%	0%	0%	8%	0%	0%	0%	0%	0%
Compliance position	+1.5	+1.5	+0.8	0.0	+0.2	-2.3	-5.4	-9.6	-14.3	-17.3
Civil penalties	-	-	-	-	-	341	827	1,439	2,207	2,610
GM										
Share eligible	1%	0%	0%	0%	0%	1%	0%	0%	0%	0%
Compliance position	+0.2	0.0	-0.8	-1.8	-1.2	-3.2	-7.1	-11.2	-15.8	-19.0
Civil penalties	-	-	120	278	181	474	1,087	1,679	2,438	2,866
Stellantis										
Share eligible	2%	0%	7%	0%	0%	0%	0%	0%	0%	0%
Compliance position	0.0	-0.2	+0.5	-0.4	-1.5	-3.3	-7.4	-9.6	-14.2	-19.5
Civil penalties	-	15	-	62	226	489	1,087	1,439	2,191	2,942
Honda										
Share eligible	0%	8%	0%	0%	0%	0%	0%	0%	0%	0%
Compliance position	+1.3	+1.6	+1.0	+2.3	+0.8	-1.9	-5.0	-9.0	-10.8	-16.8
Civil penalties	-	-	-	-	-	282	766	1,349	1,667	2,535
Subaru										
Share eligible	0%	22%	32%	21%	0%	0%	0%	0%	0%	0%
Compliance position	+0.4	+0.3	+1.7	+3.6	+1.9	-3.8	-6.3	-4.4	-3.5	-10.4
Civil penalties	-	-	-	-	-	563	965	659	540	1,569
Nissan										
Share eligible	0%	56%	0%	0%	0%	0%	0%	0%	0%	0%
Compliance position	-1.4	+0.3	0.0	+2.8	+1.5	-5.2	-3.2	-7.0	-5.9	-11.8
Civil penalties	44	-	-	-	-	608	490	1,049	910	1,780

Share eligible: Share of manufacturer fleet model year sales eligible for redesign that are conventional or MHEV powertrain.
Compliance position: Manufacturer fleet achieved fuel economy relative to standard.
Civil penalties: Average manufacturer fleet civil penalties in dollars per vehicle.

In terms of manufacturers' ability to comply with different regulatory alternatives given existing redesign schedules, results for the light truck fleet under the No ZEV alternative baseline did not vary significantly from the results presented in Table VI–2 for the reference case baseline analysis. Manufacturer light truck shortfalls under PC6LT8 were still nearly universal, with maximum shortfalls reaching more than 19 mpg, higher than the shortfalls under the reference case baseline. Ford, GM, and Nissan light truck penalties are almost identical under both baselines. Under the No ZEV alternative baseline analysis, Toyota still pays no light truck penalties under PC2LT002, and generally lower penalties under PC6LT8. Stellantis pays slightly higher penalties under PC2LT002, and generally lower penalties under PC6LT8. Honda and Subaru still pay no penalties under PC2LT002 and pay somewhat higher penalties under PC6LT8.

Table VI-6: Manufacturer Fleet Status Summary Under No ZEV Alternative Baseline, Passenger Car[1046]

	PC2LT002					PC6LT8				
	2027	**2028**	**2029**	**2030**	**2031**	**2027**	**2028**	**2029**	**2030**	**2031**
Toyota										
Share eligible	0%	0%	0%	4%	8%	0%	0%	0%	0%	0%
Compliance position	+0.7	-0.1	-1.5	+2.5	+2.8	-1.9	-5.4	-9.9	-7.2	-9.3
Civil penalties	11	77	214	-	-	282	827	1,473	1,273	1,482
Honda										
Share eligible	0%	27%	0%	0%	0%	0%	0%	0%	0%	0%
Compliance position	0.0	+4.2	+5.2	+3.0	+0.7	-1.9	+10.0	+11.6	+5.5	-0.5
Civil penalties	-	-	-	-	-	282	-	-	-	75
Nissan										
Share eligible	0%	0%	0%	0%	9%	0%	0%	0%	0%	0%
Compliance position	+2.3	+0.5	-1.5	-0.5	+0.4	-0.3	-2.8	-7.9	-10.0	-10.9
Civil penalties	64	266	434	179	-	343	865	1,345	1,485	1,612
Hyundai										
Share eligible	6%	0%	2%	0%	0%	0%	0%	0%	0%	0%
Compliance position	+4.0	+1.6	+3.6	+1.3	+2.2	+4.4	-0.9	-0.3	-6.3	-9.1
Civil penalties	-	-	-	-	-	-	371	276	1,150	1,533
Tesla										
Share eligible	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Compliance position	+325	+183	+117	+78.9	+77.6	+323	+178	+109	+68.2	+63.6
Civil penalties	-	-	-	-	-	-	-	-	-	-
GM										
Share eligible	0%	0%	0%	0%	7%	0%	0%	0%	0%	0%
Compliance position	+1.7	-1.0	+1.9	+0.2	+2.1	-0.9	-6.4	-6.5	-11.6	-12.0
Civil penalties	8	152	38	-	-	142	992	980	1,788	1,751

[1046] The passenger car fleet contains both domestic and imported car fleets. Shortfalls can occur in one fleet while the overall passenger car fleet remains in compliance. This could result in estimiated civil penalties with a positive compliance positon, as in the case of Nissan in model year 2027.

	PC2LT002					PC6LT8				
	2027	2028	2029	2030	2031	2027	2028	2029	2030	2031
Kia										
Share eligible	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%
Compliance position	-0.4	-0.5	+0.5	+0.9	+0.6	-3.0	-5.8	-5.8	-3.1	-1.8
Civil penalties	59	89	114	-	-	448	896	1,070	586	274
VWA										
Share eligible	0%	18%	0%	0%	0%	0%	0%	0%	0%	0%
Compliance position	+1.8	+5.4	+1.7	-1.7	-0.7	-0.9	+3.9	-2.9	-10.1	-13.2
Civil penalties	55	-	-	373	280	427	-	626	1,562	2,018

Share eligible: Share of manufacturer fleet model year sales eligible for redesign that are conventional or MHEV powertrain.

Compliance position: Manufacturer fleet achieved fuel economy relative to standard.

Civil penalties: Average manufacturer fleet civil penalties in dollars per vehicle.

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For passenger car shortfalls, the use of the No ZEV alternative baseline does not change much for Hyundai, Kia, VWA, Tesla, or GM (which in GM's case, illustrates that most of GM's compliance difficulty is in its light truck fleet), when comparing the results of the above table with Table VI–3. Toyota and Honda see higher passenger car penalties under the No ZEV alternative baseline for both PC2LT002 and PC6LT8, with fewer opportunities for redesigns. Nissan sees higher penalties under the No ZEV alternative baseline even though redesign opportunities are nearly identical.

Based on these results, which are generally quite similar to those under the reference case baseline, NHTSA finds that using the No ZEV alternative baseline would not change our conclusions regarding the technological feasibility of the various action alternatives.

(2) Economic Practicability

''Economic practicability'' has consistently referred to whether a standard is one ''within the financial capability of the industry, but not so stringent as to'' lead to ''adverse economic consequences, such as a significant loss of jobs or unreasonable elimination of consumer choice.''[1047] In evaluating economic practicability, NHTSA considers the uncertainty surrounding future market conditions and consumer demand for fuel economy alongside consumer demand for other vehicle attributes. There is not necessarily a bright-line test for whether a regulatory alternative is economically practicable, but there are several metrics that we discuss below that we find can be useful for making this assessment. In determining whether standards may or may not be economically practicable, NHTSA considers:[1048]

- Application rate of technologies—whether it appears that a regulatory alternative would impose undue burden on manufacturers in either or both the near and long term in terms of how much and which technologies might be required. This metric connects to other metrics, as well.

The States and Cities commented that the differences in technology penetration rates between the proposed standards and Alternative PC3LT5 were ''minimal,'' arguing that ''Where differences do exist, such as in the degree of strong hybrids and mass reduction improvements applied, [they] represent a modest additional burden for manufacturers that is lower than or similar to the technology application rates for passenger cars estimated for past rulemakings.''[1049] That commenter stated further that ''While the differences in degree of strong hybrid and mass reduction improvements estimated for light trucks in the current versus previous rulemaking is more moderate, . . . it does not make the standards economically impracticable.''[1050] CEI commented that ''The EV sales projections informing. . .NHTSA's regulatory proposal[is] based in significant part on California's EPCA-preempted ZEV program.''[1051]

NHTSA explored technology penetration rates above in the context of technological feasibility; for economic practicability, the question becomes less about ''does the technology exist and could it be applied'' and more about ''if manufacturers were to apply it at the rates NHTSA's analysis suggests, what would the economic consequences be?'' The States and Cities argue that the additional burden of applying additional ICE/vehicle-based technology would be ''modest'' and ''not economically impracticable,'' while CEI argues that NHTSA's analysis relies unduly and inappropriately on EVs. In response, NHTSA notes again that our analysis does not allow BEVs to be added in response to potential new CAFE standards, although it does recognize the existence of BEVs added during standard-setting years for non-CAFE reasons.[1052] In their comments, the automotive industry dwells heavily on the difficulty of building BEVs for reasons other than the proposed standards, and suggests that having to make any fuel economy improvements to their ICEVs in response to the CAFE program would be economically impracticable and ruinous to their other technological efforts. NHTSA has considered these comments carefully.

[1047] 67 FR 77015, 77021 (Dec. 16, 2002).

[1048] The Institute for Energy Research argued that NHTSA had ''deliberate[ly]'' failed to propose ''any alternative that . . . meet[s] the threshold for economic practicability,'' and that NHTSA was ''thus asserting that economic practicability is a factor that can be disregarded at the agency's whim.'' Institute for Energy Research, NHTSA–2023–0022–63063, Attachment 1, at 2. In response, NHTSA grappled extensively with the economic practicability of the regulatory alternatives, *see, e.g.,* 88 FR at 56328–56350 (Aug. 17, 2023), and concluded that (for purposes of the proposal) the PC2LT4 alternative was economically practicable but the more stringent alternatives likely were not. NHTSA does not understand how the commenter reached its conclusion that NHTSA disregarded economic practicability.

[1049] States and Cities, Docket No. NHTSA–2023–0022–61904, Attachment 2, at 31.

[1050] *Id.*

[1051] CEI, Docket No. NHTSA–2023–0022–61121, Attachment 1, at 8.

[1052] *See* Section IV above for more discussion on this topic.

NHTSA may be prohibited from considering the fuel economy of BEVs in determining maximum feasible CAFE standards, but NHTSA does not believe that it is prohibited from considering *the industry resources needed to build BEVs,* and industry is adamant that the resource load that it faces as part of this technological transition is unprecedented. As such, it appears that the economic-practicability tolerance of technological investment other than what manufacturers already intended to invest must be lower than NHTSA assumed in the NPRM. NHTSA recognizes, as discussed above in the technological feasibility section, that refresh and redesign schedules included in the analysis (in response to manufacturer comments to NHTSA rulemakings over the last decade or more) limit opportunities in the analysis for manufacturers to apply new technologies in response to potential future standards.[1053] While this is a limitation, it is consistent with and a proxy for actual manufacturing practice. The product design cycle assumptions are based in manufacturer comments regarding how they manage the cost to design new models, retool factories, coordinate spare parts production, and train workers to build vehicles that accommodate new technologies. The product design cycle also allows products to exist in the market long enough to recoup (at least some of) these costs. Changing these assumptions, or assuming shorter product design cycles, would likely increase the resources required by industry and increase costs significantly in a way that NHTSA's analysis currently does not capture. Increasing costs significantly would distract industry's focus on the unprecedented technology transition, which industry has made clear it cannot afford to do. NHTSA therefore recognizes the refresh and redesign cycles as a very real limitation on economic practicability in the time frame of the final standards.

- Other technology-related considerations—related to the application rate of technologies, whether it appears that the burden on several or more manufacturers might cause them to respond to the standards in ways that compromise, for example, vehicle safety, or other aspects of performance that may be important to consumer acceptance of new products.

The Alliance commented that ‘‘Manufacturers have a limited pool of human and capital resources to invest in new vehicles and powertrains,’’ and argued that it would not be ‘‘economically practicable to invest the resources necessary to achieve both the non-EV improvements envisioned and the increase in EV market share envisioned.’’ [1054] Kia provided similar comments. Mitsubishi similarly expressed concern that the proposal would cause OEMs to spend resources on ICE technology ‘‘that would otherwise be better used to accelerate the launch of new electric vehicle platforms.’’ [1055]

As with the comments about technology penetration rates, while NHTSA does not consider the technological transition itself in determining maximum feasible standards, NHTSA does acknowledge the resources needed to make that transition and agrees that manufacturers have a limited pool of human and capital resources. That said, manufacturers' comments suggest that they believe that NHTSA is demanding specific types of technological investments to comply with CAFE standards. NHTSA reiterates that the CAFE standards are performance-based standards and NHTSA does not require any specific technologies to be employed to meet the standards. Moreover, NHTSA notes numerous recent manufacturer announcements of new HEV and PHEV models.[1056] The central (statutorily-constrained) analysis for the final rule happens to reflect these recent technological developments, particularly in the early (pre-rulemaking time frame) years of the analysis. For model year 2026, the analysis shows a fleetwide sales-weighted average of combined SHEV and PHEV technology penetration of 7 percent for passenger cars and 24 percent for light trucks. This occurs in parallel with an estimated fleetwide sales-weighted average BEV technology penetration of 31 percent for passenger cars and 14 percent for light trucks. The analysis reflects the possibility that initial BEV offerings might fall in the passenger car market, as well as the rise of hybrid powertrain designs (perhaps as a transitional technology) early in the larger technology transition. We note that no significant additional advanced engine technology is introduced to the fleet in the analysis, across the alternatives. As stringency increases, the analysis mostly applies higher volumes of strong hybrid technologies. NHTSA thus concludes that given the announcements discussed above, the central analysis does in fact represent a reasonable path to compliance for industry (even if it is not the only technology path that industry might choose) that allows for a high level of resource focus by not requiring significant investments in technology beyond what they may already plan to apply.

- Cost of meeting the standards—even if the technology exists and it appears that manufacturers can apply it consistent with their product cadence, if meeting the standards is estimated to raise per-vehicle cost more than we believe consumers are likely to accept, which could negatively impact sales and employment in the automotive sector, the standards may not be economically practicable. While consumer acceptance of additional new vehicle cost associated with more stringent CAFE standards is uncertain, NHTSA still finds this metric useful for evaluating economic practicability.

IPI commented that NHTSA's compliance costs were very likely overstated due to the statutory constraints, and that ‘‘While NHTSA reasonably omits these features from its consideration due to its statutory constraints and should maintain that approach, it is particularly odd for NHTSA to prioritize compliance costs unduly as a basis to reject the most net-beneficial alternative when it knows that those costs are overestimates.’’ [1057] Rivian also commented that NHTSA's statutory constraints inflate the apparent cost of compliance, and suggested that NHTSA look at the feasibility of potential standards instead of at their cost.[1058] An individual citizen commented that it appeared NHTSA had proposed lower standards than would otherwise be feasible out of

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[1053] See TSD Chapter 2.6 for discussions on Product Design Cycle.

[1054] The Alliance, Docket No. NHTSA–2023–0022–60652, Attachment 2, at 8.

[1055] Mitsubishi, Docket No. NHTSA–2023–0022–61637, at 2.

[1056] *See, e.g.,* ‘‘GM to release plug-in hybrid electric vehicles, backtracking on product plans,’’ cnbc.com, Jan. 30, 2024, *at https://www.cnbc.com/2024/01/30/gm-to-release-plug-in-hybrid-vehicles-backtracking-on-product-plans.html*; ‘‘As Ford loses billions on EVs, the company embraces hybrids,’’ *cnbc.com,* Jul. 28, 2023, *at https://www.cnbc.com/2023/07/28/ford-embraces-hybrids-as-it-loses-billions-on-evs.html*; ‘‘Here's why plug-in hybrids are gaining momentum,’’ Automotive News, Mar. 7, 2024, *at https://www.autonews.com/mobility-report/phevs-can-help-introduce-evs-reduce-emissions;* ‘‘Genesis will reportedly launch its first hybrid models in 2025,’’ autoblog.com, Feb. 20, 2024, *at https://www.autoblog.com/2024/02/20/genesis-will-reportedly-launch-its-first-hybrid-models-in-2025/?guccounter=1&guce_referrer=aHR0cHM6Ly93d3cuZ29vZ2xlLmNvbS8&guce_referrer_sig=AQAAAEX5xWHtRIyg5otwKBUziml8MrkD5He-xxjOQdFZCnodUbvrtwUljfJ9IHSovY9JtYQjTUDDcjV4Zz1ZWrMu7VE9D037IhYTi_wfNPEI6aXzC-bbvrRVi2hkM3sqsGQBqFPgAVh_MK6WDqt1rNA25b14UovtiNgzQr6wpwp2iORi.*

[1057] IPI, Docket No. NHTSA–2023–0022–60485, at 12.

[1058] Rivian, Docket No. NHTSA–2023–0022–59765, at 3.

concern about costs, and stated that NHTSA should reconsider ''in light of recent news of the exorbitant personal annual CEO compensations for the Big Three automobile manufacturers, $75 million, combined,'' suggesting that perhaps all costs associated with technology application did not need to be passed fully on to consumers.[1059] The States and Cities stated that the per-vehicle costs associated with the proposed standards and Alternative PC3LT5 ''are both reasonable and lower than past estimates of average price change.'' [1060]

In contrast, Landmark stated that ''NHTSA admits'' that the projected costs due to meeting potential future standards would be passed forward to consumers as price increases, and that ''The Proposed Rule would punish consumers of passenger cars.'' [1061] MOFB commented that increased vehicle prices would ''apply disproportionate burden on [its] members.'' [1062] Jaguar commented that the proposed revisions to the PEF resulted in increased compliance costs and ''a weaker business case,'' which ''could push automakers to limit BEVs to more profitable markets.'' [1063] Jaguar also expressed concerns about volatility for critical minerals pricing that could further affect per-vehicle costs.[1064] AAPC commented that NHTSA's analysis showed that the projected per-vehicle cost was ''over three times greater'' for the Detroit 3 automakers than for the rest of the industry, and that this ''directly results from DOE's proposed reduction of the PEF for EVs and NHTSA's proposal to require drastically faster fuel economy improvements from trucks as compared to cars.'' [1065] AAPC argued that DOE and NHTSA were deliberately pursuing policies contrary to Administration goals, and that doing so would ''benefit[ ] foreign auto manufacturers'' and ''unfairly harm[ ] the [Detroit 3] and its workforce.'' [1066]

Several commenters stated that the proposed standards would require an unduly expensive transition to BEVs. KCGA argued that ''EVs actively lose companies money and require subsidization to remain competitive,'' and that ''Scaling would be one of the biggest challenges. . . .'' [1067] The American Consumer Institute stated that among the ''obstacles to a sudden and immediate electrification of the fleet,'' ''The price differential between an EV and an ICE vehicle still exceeds $10,000, which poses a staggering disparity in upfront costs alone.'' [1068] AHUA echoed these concerns, stating that ''the price of an EV was more than double the price of a subcompact car,'' and that ''This represents a real financial challenge for middle class families that need a basic vehicle to get to work, health care, the grocery store, and other fundamental destinations, and for local business travel, such as meetings and sales calls, particularly for small businesses.'' [1069] SEMA argued that ''the only way for OEMs to comply with the proposed standards is to rapidly increase sales of electric vehicles and sell fewer ICE vehicles,'' and that ''The alternative is . . . to pay massive fines. . . .'' [1070] SEMA also stated that electric vehicles were much more expensive than ICE vehicles, and that consumers would also be required to spend extra money on home vehicle chargers.[1071] AFPM commented that NHTSA was ''ignor[ing]'' cross-subsidization of vehicles by manufacturers, and that ''NHTSA must account for these real-world costs and communicate to the public that these cross-subsidies must be paid for by a shrinking number of ICEV buyers and, therefore, must significantly increase the average price of EVs.'' [1072] Heritage Foundation offered similar comments about cross-subsidization and also expressed concern about battery costs and lack of charging infrastructure.[1073]

In response, NHTSA agrees that the statutory constraints lead to different analytical results (including per-vehicle costs) than if the statutory constraints were not included in the analysis, but the agency is bound to consider the facts as they appear within the context of that constrained analysis. Also within that context, NHTSA agrees with commenters who point out that some companies appear to struggle more than others to meet the different regulatory alternatives. After considering the comments, NHTSA understands better that manufacturers' tolerance for technology investments other than those they have already chosen to make is much lower than NHTSA previously understood. The updated per-vehicle costs for each fleet, each manufacturer, and the boundary cases for considered regulatory alternatives are as follows:

[1059] Roselie Bright, Docket No. NHTSA–2022–0075–0030–0004.

[1060] States and Cities, Docket No. NHTSA–2022–0075–0033, Attachment 2, at 30.

[1061] Landmark, Docket No. NHTSA–2023–0022–48725, Attachment 1, at 4.

[1062] MOFB, Docket No. NHTSA–2023–0022–61601, at 1.

[1063] Jaguar, Docket No. NHTSA–2023–0022–57296, Attachment 1, at 6.

[1064] *Id.*

[1065] AAPC, Docket No. NHTSA–2023–0022–60610, at 5.

[1066] *Id.*

[1067] KCGA, Docket No. NHTSA–2023–0022–59007, at 3.

[1068] American Consumer Institute, Docket No. NHTSA–2023–0022–50765, Attachment 1, at 2.

[1069] AHUA, Docket No. NHTSA–2023–0022–58180, at 4.

[1070] SEMA, Docket No. NHTSA–2023–0022–57386, Attachment 1, at 2.

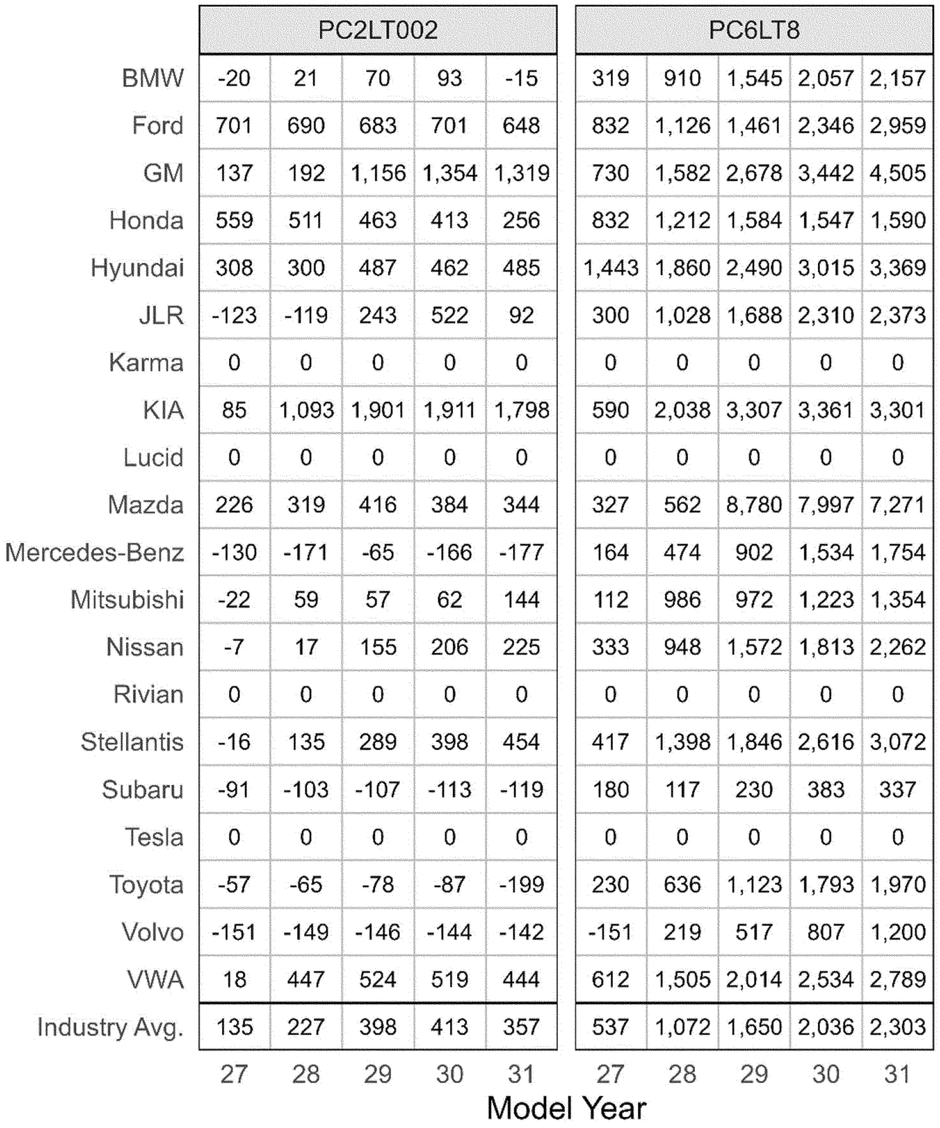
[1071] *Id.*

[1072] AFPM, Docket No. NHTSA–2023–0022–61911, Attachment 2, at 67.

[1073] Heritage Foundation, Docket No. NHTSA–2023–0022–61952, at 6, 7.

Figure VI-7: Estimated Average Price Change (Regulatory Cost) for Passenger Cars

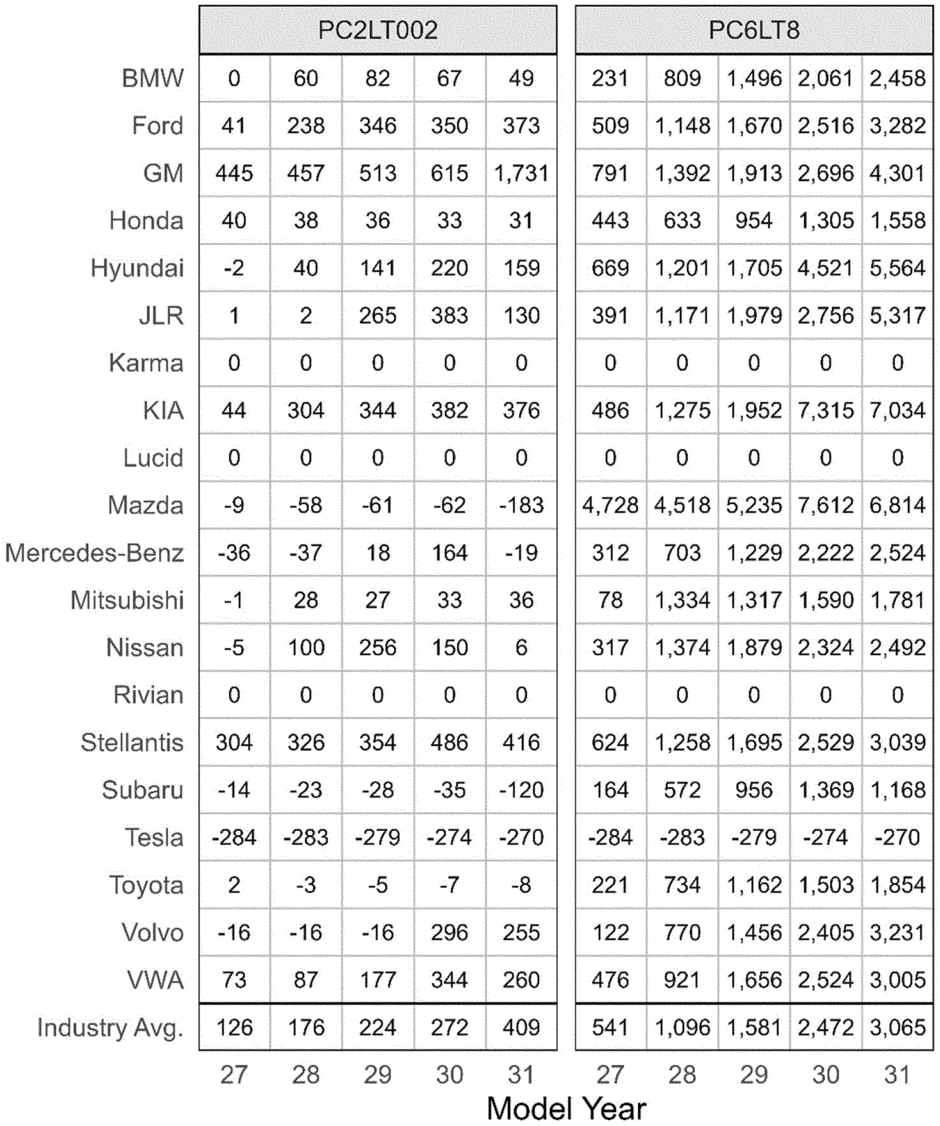
(2021$, vs. No-Action Alternative)



	PC2LT002					PC6LT8				
BMW	-20	21	70	93	-15	319	910	1,545	2,057	2,157
Ford	701	690	683	701	648	832	1,126	1,461	2,346	2,959
GM	137	192	1,156	1,354	1,319	730	1,582	2,678	3,442	4,505
Honda	559	511	463	413	256	832	1,212	1,584	1,547	1,590
Hyundai	308	300	487	462	485	1,443	1,860	2,490	3,015	3,369
JLR	-123	-119	243	522	92	300	1,028	1,688	2,310	2,373
Karma	0	0	0	0	0	0	0	0	0	0
KIA	85	1,093	1,901	1,911	1,798	590	2,038	3,307	3,361	3,301
Lucid	0	0	0	0	0	0	0	0	0	0
Mazda	226	319	416	384	344	327	562	8,780	7,997	7,271
Mercedes-Benz	-130	-171	-65	-166	-177	164	474	902	1,534	1,754
Mitsubishi	-22	59	57	62	144	112	986	972	1,223	1,354
Nissan	-7	17	155	206	225	333	948	1,572	1,813	2,262
Rivian	0	0	0	0	0	0	0	0	0	0
Stellantis	-16	135	289	398	454	417	1,398	1,846	2,616	3,072
Subaru	-91	-103	-107	-113	-119	180	117	230	383	337
Tesla	0	0	0	0	0	0	0	0	0	0
Toyota	-57	-65	-78	-87	-199	230	636	1,123	1,793	1,970
Volvo	-151	-149	-146	-144	-142	-151	219	517	807	1,200
VWA	18	447	524	519	444	612	1,505	2,014	2,534	2,789
Industry Avg.	135	227	398	413	357	537	1,072	1,650	2,036	2,303
	27	28	29	30	31	27	28	29	30	31

Model Year

Figure VI-8: Estimated Average Price Change (Regulatory Cost) for Light Trucks (2021$, vs. No-Action Alternative)



	PC2LT002					PC6LT8				
BMW	0	60	82	67	49	231	809	1,496	2,061	2,458
Ford	41	238	346	350	373	509	1,148	1,670	2,516	3,282
GM	445	457	513	615	1,731	791	1,392	1,913	2,696	4,301
Honda	40	38	36	33	31	443	633	954	1,305	1,558
Hyundai	-2	40	141	220	159	669	1,201	1,705	4,521	5,564
JLR	1	2	265	383	130	391	1,171	1,979	2,756	5,317
Karma	0	0	0	0	0	0	0	0	0	0
KIA	44	304	344	382	376	486	1,275	1,952	7,315	7,034
Lucid	0	0	0	0	0	0	0	0	0	0
Mazda	-9	-58	-61	-62	-183	4,728	4,518	5,235	7,612	6,814
Mercedes-Benz	-36	-37	18	164	-19	312	703	1,229	2,222	2,524
Mitsubishi	-1	28	27	33	36	78	1,334	1,317	1,590	1,781
Nissan	-5	100	256	150	6	317	1,374	1,879	2,324	2,492
Rivian	0	0	0	0	0	0	0	0	0	0
Stellantis	304	326	354	486	416	624	1,258	1,695	2,529	3,039
Subaru	-14	-23	-28	-35	-120	164	572	956	1,369	1,168
Tesla	-284	-283	-279	-274	-270	-284	-283	-279	-274	-270
Toyota	2	-3	-5	-7	-8	221	734	1,162	1,503	1,854
Volvo	-16	-16	-16	296	255	122	770	1,456	2,405	3,231
VWA	73	87	177	344	260	476	921	1,656	2,524	3,005
Industry Avg.	126	176	224	272	409	541	1,096	1,581	2,472	3,065
	27	28	29	30	31	27	28	29	30	31

Model Year

Even though per-vehicle costs are quite low in some instances compared to what NHTSA has considered economically practicable in the past, they are still fairly high for others, and quite high for some individual manufacturers, like Kia and Mazda. Moreover, companies have made it clear that they cannot afford to make any further technology investments (which would result in higher per-vehicle costs) if they are to successfully undertake the technological transition that NHTSA cannot consider directly, due to constraints on research and production budgets. The idea that CEO compensation could be repurposed to research and production is innovative but not within NHTSA's control, so NHTSA cannot assume that companies would choose that approach.

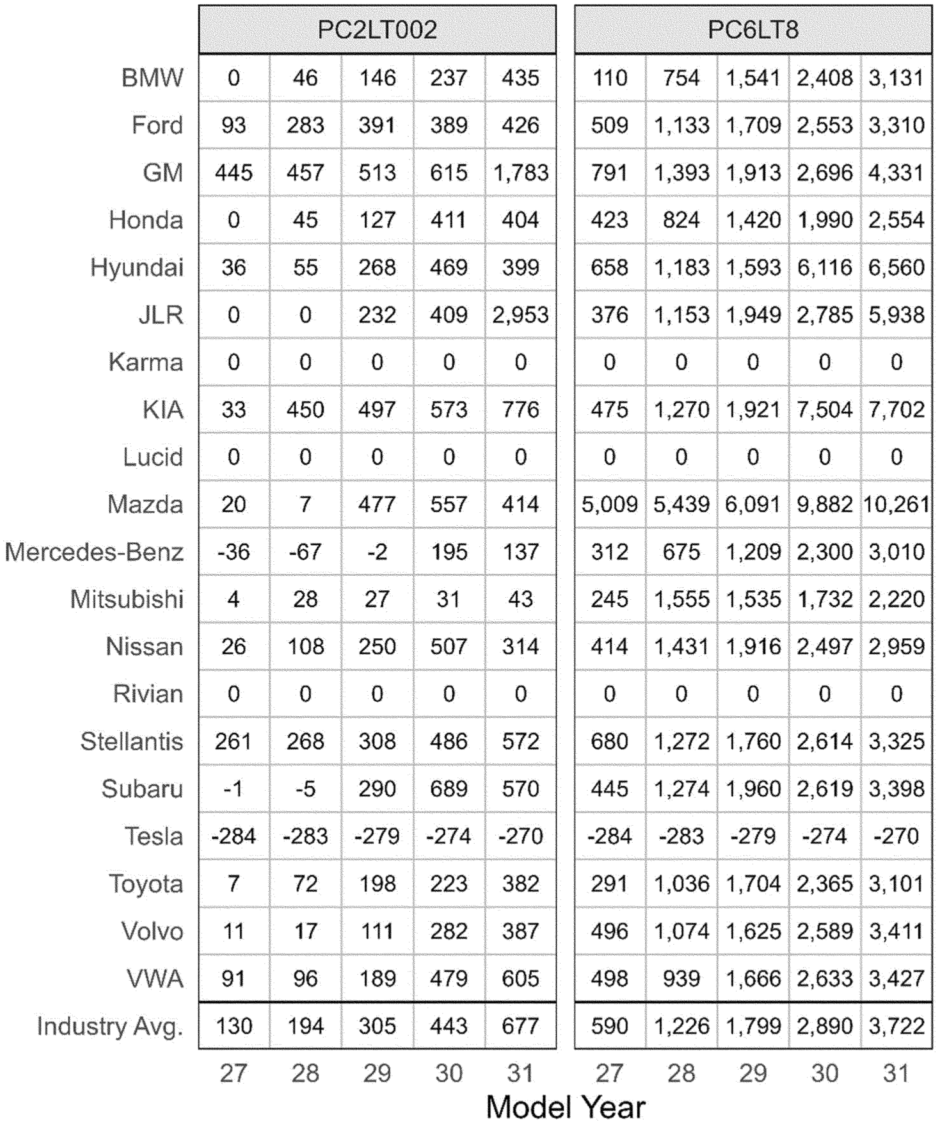
As discussed above, NHTSA also conducted a ''No ZEV alternative baseline'' analysis. Estimated average price change (regulatory cost) under the No ZEV alternative baseline, as compared to the reference case baseline, varies by manufacturer.

Figure VI-9: Estimated Average Price Change (Regulatory Cost) for Passenger Cars Under No ZEV Alternative Baseline (2021$, vs. No-Action Alternative)

	PC2LT002					PC6LT8				
BMW	1	86	291	675	611	231	992	1,800	2,638	3,113
Ford	848	834	825	841	801	875	1,166	1,599	2,544	3,223
GM	137	192	1,156	1,354	1,457	729	1,582	2,678	3,442	4,599
Honda	-572	-283	-43	-50	-180	252	1,593	2,062	2,180	2,363
Hyundai	206	200	576	521	609	1,491	1,929	2,570	3,139	3,821
JLR	-118	-115	210	596	365	300	1,046	1,702	2,367	2,673
Karma	0	0	0	0	0	0	0	0	0	0
KIA	69	1,074	1,887	1,929	1,929	574	2,039	3,296	3,506	3,687
Lucid	0	0	0	0	0	0	0	0	0	0
Mazda	108	156	2,851	2,833	2,797	228	1,167	10,364	10,530	10,830
Mercedes-Benz	-128	-168	-25	-133	27	163	475	913	1,625	2,122
Mitsubishi	-10	157	155	283	353	496	1,039	1,026	1,576	2,153
Nissan	32	155	280	511	588	457	1,017	1,646	2,043	2,761
Rivian	0	0	0	0	0	0	0	0	0	0
Stellantis	-14	121	298	493	839	772	1,549	2,049	2,752	3,252
Subaru	-108	-114	1,186	1,182	1,168	609	1,204	1,503	1,423	2,086
Tesla	0	0	0	0	0	0	0	0	0	0
Toyota	-42	93	224	634	677	330	1,020	1,805	2,818	3,383
Volvo	-105	-74	-7	35	200	125	386	599	1,272	1,625
VWA	18	323	421	571	671	623	1,390	1,909	2,651	3,157
Industry Avg.	-26	146	454	594	629	518	1,244	1,912	2,443	2,948
	27	28	29	30	31	27	28	29	30	31

Model Year

Figure VI-10: Estimated Average Price Change (Regulatory Cost) for Light Trucks Under No ZEV Alternative Baseline (2021$, vs. No-Action Alternative)



	PC2LT002					PC6LT8				
BMW	0	46	146	237	435	110	754	1,541	2,408	3,131
Ford	93	283	391	389	426	509	1,133	1,709	2,553	3,310
GM	445	457	513	615	1,783	791	1,393	1,913	2,696	4,331
Honda	0	45	127	411	404	423	824	1,420	1,990	2,554
Hyundai	36	55	268	469	399	658	1,183	1,593	6,116	6,560
JLR	0	0	232	409	2,953	376	1,153	1,949	2,785	5,938
Karma	0	0	0	0	0	0	0	0	0	0
KIA	33	450	497	573	776	475	1,270	1,921	7,504	7,702
Lucid	0	0	0	0	0	0	0	0	0	0
Mazda	20	7	477	557	414	5,009	5,439	6,091	9,882	10,261
Mercedes-Benz	-36	-67	-2	195	137	312	675	1,209	2,300	3,010
Mitsubishi	4	28	27	31	43	245	1,555	1,535	1,732	2,220
Nissan	26	108	250	507	314	414	1,431	1,916	2,497	2,959
Rivian	0	0	0	0	0	0	0	0	0	0
Stellantis	261	268	308	486	572	680	1,272	1,760	2,614	3,325
Subaru	-1	-5	290	689	570	445	1,274	1,960	2,619	3,398
Tesla	-284	-283	-279	-274	-270	-284	-283	-279	-274	-270
Toyota	7	72	198	223	382	291	1,036	1,704	2,365	3,101
Volvo	11	17	111	282	387	496	1,074	1,625	2,589	3,411
VWA	91	96	189	479	605	498	939	1,666	2,633	3,427
Industry Avg.	130	194	305	443	677	590	1,226	1,799	2,890	3,722
	27	28	29	30	31	27	28	29	30	31

Model Year

As under the reference baseline analysis, even though per-vehicle costs are quite low in some instances under the No ZEV alternative baseline compared to what NHTSA has considered economically practicable in the past, they are still fairly high for others, and quite high for some individual manufacturers, like Kia and Mazda. Costs under the No ZEV alternative baseline analysis are somewhat higher than under the reference baseline analysis, particularly for passenger cars, but not by enough to change the agency's conclusions about the general direction of per-vehicle cost increases. As explained above, companies have made it clear that they cannot afford to make any further technology investments (which would result in higher per-vehicle costs) if they are to successfully undertake the technological transition that NHTSA cannot consider directly, due to constraints on research and production budgets. Additional costs would exacerbate that situation.

With regard to the comments discussing perceived BEV costs, NHTSA reiterates that CAFE standards are performance-based standards and not technology mandates, and companies are free to choose their own compliance path with their own preferred technological approach. The comments suggesting that NHTSA ignores cross-subsidization may not have sufficiently considered the NPRM discussion on manufacturer pricing strategies.[1074] NHTSA stated, and reiterates elsewhere in this final rule, that while the agency recognizes that some manufacturers may defray their regulatory costs through more complex pricing strategies or by accepting lower profits, NHTSA lacks sufficient insight into these practices to confidently model alternative approaches. Manufacturers tend to be unwilling to discuss these practices publicly or even privately with much specificity. Without better information, NHTSA believes it is more prudent to

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[1074] 88 FR at 56249 (Aug. 17, 2023).

continue to assume that manufacturers raise the prices of models whose fuel economy they elect to improve sufficiently to recover their increased costs for doing so, and then pass those costs forward to buyers as price increases. Any stakeholders who might wish to provide more information on cross-subsidization that could improve the realism of NHTSA's future analyses are invited to do so.

A number of commenters discussed the estimated civil penalties for non-compliance shown in the analysis for the NPRM. Civil penalties are a component of per-vehicle cost increases because NHTSA assumes that they (like technology costs) are passed forward to new vehicle buyers.

Jaguar commented that all of the regulatory alternatives were beyond maximum feasible for Jaguar, because NHTSA's analysis showed Jaguar paying civil penalties under all regulatory alternatives.[1075] The Alliance and Kia argued more broadly that automaker non-compliance at the level of the proposed standards ''exceeds reason'' and ''will increase costs to the American consumer with absolutely no environmental or fuel savings benefits.'' [1076] AAPC made a similar point.[1077] Kia stated further that ''Kia and the industry as a whole cannot afford to pay billions in civil penalties for CAFE non-compliance while also investing billions of dollars in the EV transition and EPA GHG regulation compliance.'' [1078] MEMA stated that ''money spent on noncompliance fines is money not spent on technology investment or workforce training,'' and argued that these ''lost funds and unrealized improvements'' should be factored into the analysis. Toyota commented that the amount of civil penalties projected showed ''that the technology being relied upon is insufficient to achieve the proposed standards.'' [1079] BMW stated that NHTSA had forecast penalties for BMW over the rulemaking time frame of roughly $4.7 billion, and that the standards were therefore not economically practicable because ''By its own admission, NHTSA has proposed a rule which is prohibitive to doing business in the U.S. market for BMW.''[1080] Ford similarly commented that while NHTSA had acknowledged in the NPRM that Ford had never paid civil penalties under the CAFE program, NHTSA's analysis demonstrated that Ford would ''likely pay $1 billion in civil penalties if NHTSA's proposal were finalized,'' making the proposed standards infeasible.[1081] Stellantis offered similar comments, and also stated that ''The PEF adjustment combined with the proposed NHTSA rule forces fines with insufficient time to adjust plans.'' [1082] The Alliance further stated that when it ran the CAFE model with civil penalties turned off, many fleets were unable to meet the standards, which made the proposed standards arbitrary and capricious.[1083]

Valero commented that ''It is inappropriate and unlawful for NHTSA to set standards that are so stringent that manufacturers cannot comply without the use of civil penalties,'' and stated that such standards would not be economically practicable.[1084] POET commented that the proposal ''dictates that manufacturers must pay significant fines to continue in business,'' and argued that a rule that ''increase[d] manufacturer fines by multiple billions of dollars'' was neither technologically feasible nor economically practicable.[1085] Heritage Foundation offered similar comments,[1086] as did U.S. Chamber of Commerce, who suggested that standards that drove up vehicle prices (through manufacturers passing civil penalties forward to consumers as price increases) without improving efficiency must be beyond economically practicable.[1087] Landmark also offered similar comments, stating that ''The government is seeking to force companies toward greater production of EVs by heavily penalizing them for failing to comply with completely unreasonable standards.''[1088]

The Alliance argued further that analysis showing significant potential payment of civil penalties necessarily demonstrated that standards were economically impracticable, because NHTSA has consistently recognized that automakers are always free to pay penalties if they cannot meet the standards, meaning that ''in the light-duty context, the civil penalties effectively set an upper limit on economic practicability.'' [1089] The Alliance stated that NHTSA was incorrect to suggest in the NPRM that ''moderating [its] standards in response to [civil penalty estimates] would . . . risk 'keying standards to the least capable manufacturer,''' because ''these are precisely the type of 'industry-wide considerations' that NHTSA has concluded [Congress intended NHTSA to consider].'' [1090] The Alliance concluded that economic practicability ''might include standards that require a few laggards to pay penalties, but that concept cannot reasonably encompass a scenario in which the cost of compliance for a majority of the market in a given class will exceed the cost of penalties.'' [1091]

The Joint NGOs, in contrast, commented that manufacturers have the ability to use credit carry-forward and carry-back, and ''Nothing in EPCA contemplates that NHTSA will doubly account for automakers' multi-year product plans by tempering the stringency of the standard in any particular model year,'' implying that shortfalls in any given year need not indicate economic impracticability.[1092]

NHTSA has considered these comments carefully. The Joint NGOs are correct that manufacturers may carry credits forward and back, but 49 U.S.C. 32902(h) does not allow NHTSA to consider the availability of credits in determining maximum feasible CAFE standards. NHTSA is bound by the statutory constraints, and the constrained analysis for the NPRM did show several manufacturers paying civil penalties rather than achieving compliance. With the final rule updates, estimated civil penalties for the Preferred Alternative appear as follows.

[1075] Jaguar, Docket No. NHTSA–2023–0022–57296, Attachment 1, at 3.

[1076] The Alliance, Docket No. NHTSA–2023–0022–27803, Attachment 1, at 1; The Alliance, Docket No. NHTSA–2023–0022–60652, Appendix B, at 14–19; Kia, Docket No. NHTSA–2023–0022–58542–A1, at 6.

[1077] AAPC, Docket No. NHTSA–2023–0022–60610, at 6.

[1078] Kia, at 6. Ford offered similar comments: Ford, Docket No. NHTSA–2023–0022–60837, at 4.

[1079] Toyota, Docket No. NHTSA–2023–0022–61131, at 2, 12, 16.

[1080] BMW, Docket No. NHTSA–2023–0022–58614, at 3.

[1081] Ford, Docket No. NHTSA–2023–0022–60837, at 3, 6.

[1082] Stellantis, Docket No. NHTSA–2023–0022–61107, at 8–9.

[1083] Alliance, Docket No. NHTSA–2023–0022–60652, Appendix B, at 21–23.

[1084] Valero, Docket No. NHTSA–2023–0022–58547, Attachment A, at 7.

[1085] POET, Docket No. NHTSA–2023–0022–61561, Attachment 1, at 16.

[1086] Heritage Foundation, Docket No. NHTSA–2023–0022–61952, at 5.

[1087] U.S. Chamber of Commerce, Docket No. NHTSA–2023–0022–61069, Attachment 1, at 3–4. NADA offered similar comments, Docket No. NHTSA–2023–0022–58200, at 5.

[1088] Landmark, Docket No. NHTSA–2023–0022–48725, Attachment 1, at 4.

[1089] The Alliance, Docket No. NHTSA–2023–0022–60652, Appendix B, at 14.

[1090] *Id.* at 15.

[1091] *Id.*

[1092] Joint NGOs, Docket No. NHTSA–2023–0022–61944, NGO Comment Appendix, at 5.

Table VI-7: Total Civil Penalties by Manufacturer and Model Year, Preferred Alternative (PC2LT002), Passenger Cars ($2021 billions)[1093]

Manufacturer	2027	2028	2029	2030	2031	Total
BMW	-	-	-	-	-	-
Mercedes-Benz	-	-	-	-	-	-
Stellantis	0.022	0.077	0.070	0.126	0.027	0.322
Ford	-	-	-	-	-	-
GM	0.004	0.065	0.016	-	-	0.085
Honda	-	-	-	-	-	-
Hyundai	-	-	-	-	-	-
Kia	0.020	0.030	0.031	-	-	0.081
JLR	-	-	-	-	-	-
Mazda	0.001	0.003	-	-	-	0.004
Mitsubishi	-	-	-	-	-	-
Nissan	-	0.043	0.150	-	-	0.193
Subaru	-	-	-	-	-	-
Tesla	-	-	-	-	-	-
Toyota	0.007	0.014	0.007	-	-	0.028
Volvo	-	-	-	-	-	-
VWA	0.013	-	0.003	0.051	-	0.061
Karma	-	-	-	-	-	-
Lucid	-	-	-	-	-	-
Rivian	-	-	-	-	-	-
Industry Total	0.067	0.232	0.271	0.177	0.027	0.774

[1093] For comparison, the combined profits for Stellantis, GM and Ford were approximately $143 billion over the last 5 years, averaging $28.6 billion per year. See: https://www.epi.org/blog/uaw-automakers-negotiations/.

Table VI-8: Total Civil Penalties by Manufacturer and Model Year, Preferred Alternative (PC2LT002), Light Trucks ($2021 billions)

Manufacturer	2027	2028	2029	2030	2031	Total
BMW	-	-	0.011	0.006	-	0.017
Mercedes-Benz	0.007	-	0.023	-	-	0.030
Stellantis	-	-	-	0.024	0.023	0.046
Ford	-	-	-	-	-	-
GM	-	-	0.187	0.427	0.206	0.821
Honda	-	-	-	-	-	-
Hyundai	-	-	-	-	-	-
Kia	0.025	-	-	-	-	0.025
JLR	-	-	0.022	0.022	-	0.044
Mazda	-	-	-	-	-	-
Mitsubishi	-	-	-	-	-	-
Nissan	0.020	-	-	-	-	0.020
Subaru	-	-	-	-	-	-
Tesla	-	-	-	-	-	-
Toyota	-	-	-	-	-	-
Volvo	-	-	-	-	-	-
VWA	-	-	0.049	-	-	0.049
Karma	-	-	-	-	-	-
Lucid	-	-	-	-	-	-
Rivian	-	-	-	-	-	-
Industry Total	0.052	-	0.292	0.479	0.229	1.052

For comparison, civil penalties estimated in the NPRM analysis for the then-Preferred Alternative (PC2LT4) totaled $10.6 billion for the entire industry summed over the 5 years of the rulemaking time frame.[1094] Total civil penalties for the final rule under the reference baseline are estimated at an order of magnitude less, just over $1 billion for the 5-year period. For further comparison, civil penalties estimated for the 2022 final rule Preferred Alternative (Alternative 2.5) totaled $5.3 billion over 3 years for the entire industry, or approximately $1.8 billion per year, which is equivalent to the total 5-year estimate of civil penalties for the preferred alternative in this final rule.[1095]

[1094] See NHTSA, Preliminary Regulatory Impact Analysis, Corporate Average Fuel Economy Standards for Passenger Cars and Light Trucks for Model Years 2027 and Beyond and Fuel Efficiency Standards for Heavy-Duty Pickup Trucks and Vans for Model Years 2030 and Beyond, July 2023. *Available at https://www.nhtsa.gov/sites/nhtsa.gov/files/2023-08/NHTSA-2127-AM55-PRIA-tag.pdf* (last accessed May 29, 2024).

[1095] See 87 FR 25710 (May 2, 2022).

Table VI-9: Total Civil Penalties by Manufacturer and Model Year, Preferred Alternative (PC2LT002), No ZEV Alternative Baseline, Passenger Cars ($2021 billions)[1096]

Manufacturer	**2027**	**2028**	**2029**	**2030**	**2031**	**Total**
BMW	-	-	-	0.034	0.005	0.040
Mercedes-Benz	0.007	-	0.025	-	0.029	0.061
Stellantis	-	-0.024	-	0.094	0.341	0.411
Ford	-	-	-	-	-	-
GM	-	-	0.187	0.427	0.275	0.889
Honda	-	-	-	-	-	-
Hyundai	-	-	-	-	-	-
Kia	0.017	-	-	-	-	0.017
JLR	-	-	0.019	0.033	0.020	0.073
Mazda	-	-	-	-	-	-
Mitsubishi	-	-	-	-	-	-
Nissan	0.020	-	-	-	-	0.020
Subaru	-	-	-	-	-	-
Tesla	-	-	-	-	-	-
Toyota	-	-	-	-	-	-
Volvo	0.003	0.005	0.017	0.020	0.041	0.086
VWA	-	-0.006	0.043	0.012	0.012	0.061
Karma	-	-	-	-	-	-
Lucid	-	-	-	-	-	-
Rivian	-	-	-	-	-	-
Industry Total	0.047	-0.025	0.291	0.621	0.724	1.658

[1096] For comparison, the combined profits for Stellantis, GM, and Ford were approximately $143 billion over the last 5 years, averaging $28.6 billion per year. See: *https://www.epi.org/blog/uaw-automakers-negotiations/.*

Table VI-10: Total Civil Penalties by Manufacturer and Model Year, Preferred Alternative (PC2LT002), No ZEV Alternative Baseline, Light Trucks ($2021 billions)

Manufacturer	2027	2028	2029	2030	2031	Total
BMW	-	-	0.055	0.056	0.048	0.159
Mercedes-Benz	-	-	-	-	-	-
Stellantis	0.021	0.074	0.064	0.128	0.039	0.326
Ford	-	-	-	-	0.026	0.026
GM	0.004	0.065	0.016	-	-	0.085
Honda	-	-	-	-	-	-
Hyundai	-	-	-	-	-	-
Kia	0.020	0.030	0.038	-	-	0.088
JLR	-	-	-	0.000	0.001	0.001
Mazda	-	-	-	-	-	-
Mitsubishi	0.001	-	-	-	-	0.001
Nissan	0.036	0.148	0.240	0.097	-	0.520
Subaru	-	-	-	-	-	-
Tesla	-	-	-	-	-	-
Toyota	0.010	0.072	0.198	-	-	0.280
Volvo	-	-	-	-	-	-
VWA	0.013	-	-	0.088	0.065	0.167
Karma	-	-	-	-	-	-
Lucid	-	-	-	-	-	-
Rivian	-	-	-	-	-	-
Industry Total	0.105	0.389	0.611	0.369	0.180	1.654

Comparing the estimated civil penalties under the reference case and No ZEV alternative baseline analyses, NHTSA finds that civil penalties are somewhat higher—roughly $1.6 billion for both passenger cars and light trucks under the No ZEV alternative baseline analysis, compared to roughly $770 million for passenger cars and roughly $1 billion for light trucks under the reference case baseline analysis. Even the total under the No ZEV alternative baseline analysis is still considerably lower than the penalties estimated for the NPRM preferred alternative, or for the 2022 final rule. NHTSA therefore concludes that the use of the No ZEV alternative baseline rather than the reference case baseline does not result in costs that alter the agency's determination that the rule is economically feasible.

NHTSA has long interpreted economic practicability as meaning that standards should be ''within the financial capability of the industry, but not so stringent as to lead to adverse economic consequences.'' Civil penalty payment has not historically been specifically highlighted as an ''adverse economic consequence,'' due to NHTSA's assumption that manufacturers recoup those payments by increasing new vehicle prices. NHTSA continues to believe that it is reasonable to assume that manufacturers will recoup civil penalty payments, and that changes in per-vehicle costs can drive sales effects. If per-vehicle costs and sales effects appear practicable, then shortfalls by themselves would not seem to weigh any more heavily on economic practicability.

However, NHTSA is persuaded by the comments that civil penalties are money not spent on investments that could help manufacturers comply with higher standards in the future. NHTSA also agrees that civil penalties do not improve either fuel savings or emissions reductions, and thus do not directly serve EPCA's overarching purpose. As such, while NHTSA does not believe that economic practicability mandates that *zero* penalties be modeled to occur in response to potential future standards, NHTSA does believe, given the circumstances of this rule and the technological transition that NHTSA may not consider directly, that economic practicability can reasonably include the idea that high percentages of the cost of compliance should not be attributed to shortfall penalties across a wide group of manufacturers, either, because penalties are not compliance. Table VI–11 and Table VI–12 show the number of manufacturers who have shortfalls in each fleet with a regulatory cost break down for each alternative.[1097]

[1097] Values in these tables may not sum perfectly due to rounding.

Table VI-11: Compliance and Cost Summary – Passenger Cars

	PC2LT002	PC1LT3	PC2LT4	PC3LT5	PC6LT8
Compliance shortfalls in MY 2031					
Domestic car, number of manufacturers (of 13 total fleets)	0	0	0	3	4
Imported car, number of manufacturers (of 16 total fleets)	1	1	1	4	11
Total costs through MY 2031 (relative to No-Action alternative, $b)					
Technology costs	7.0	1.9	5.8	9.5	17.4
Civil penalties	0.8	0.3	0.8	2.2	13.2
Total	7.8	2.2	6.6	11.7	30.5
Civil penalties as share of total	10%	13%	12%	19%	43%

Table VI-12: Compliance and Cost Summary – Light Trucks

	PC2LT002	PC1LT3	PC2LT4	PC3LT5	PC6LT8
Compliance shortfalls in MY 2031 (of 19 total fleets)					
Number of manufacturers	2	8	8	12	14
Total costs through MY 2031 (relative to No-Action alternative, $b)					
Technology costs	11.0	19.8	27.2	31.9	38.1
Civil penalties	1.1	8.1	13.2	20.8	54.7
Total	12.0	28.0	40.4	52.7	92.8
Civil penalties as share of total	9%	29%	33%	40%	59%

As Table VI–12 shows, civil penalties as a percentage of regulatory costs rise rapidly for light trucks as alternatives increase in stringency, jumping from only 9 percent for PC2LT002 to 29 percent for PC1LT3, and rising to 59 percent for PC6LT8—that is to say, civil penalties actually outweigh technology costs for the light truck fleet under PC6LT8. The number of manufacturers facing shortfalls (and thus civil penalties, for purposes of the analysis due to the statutory prohibition against considering the availability of credits) similarly rises as alternatives increase in stringency, from only 2 out of 19 manufacturers under PC2LT002, to 8 out of 19 (nearly half) for PC1LT3, to 14 out of 19 for PC6LT8.

Table VI–11 shows that results are for the passenger car fleet. The number of manufacturers facing shortfalls (particularly in their imported car fleets) and the percentage of regulatory costs represented by civil penalties rapidly increase for the highest stringency scenarios considered, PC3LT5 and PC6LT8, such that at the highest stringency 43 percent of the regulatory cost is attributed to penalties and approximately three quarters of the 19 manufacturers are facing shortfalls. The three less stringent alternatives show only one manufacturer facing shortfalls for each of alternatives PC2LT002, PC1LT3, and PC2LT4. However, civil penalties represent higher percentages of regulatory costs under PC1LT3 and PC2LT4 than under PC2LT002. Optimizing the use of resources for technology improvement over penalties suggests PC2LT002 as the best option of the three for the passenger car fleet.

Considering this ratio as an element of economic practicability for purposes of this rulemaking, then, NHTSA believes that PC2LT002 represents the least harmful alternative considered. With nearly half of light truck manufacturers facing shortfalls under PC1LT3, and nearly 30 percent of regulatory costs being attributable to civil penalties, given the concerns raised by manufacturers regarding their ability to finance the ongoing technological transition if they must divert funds to paying CAFE penalties, NHTSA believes that PC1LT3 may be beyond economically practicable in this particular rulemaking time frame.

NHTSA also considered civil penalties as a percentage of regulatory costs under the No ZEV alternative baseline, as follows:

Table VI-13: Compliance and Cost Summary – Passenger Cars – No ZEV Alternative

Baseline

	PC2LT002	PC1LT3	PC2LT4	PC3LT5	PC6LT8
Compliance shortfalls in MY 2031					
Domestic car, number of manufacturers (of 13 total fleets)	2	0	2	4	6
Imported car, number of manufacturers (of 16 total fleets)	4	2	4	7	12
Total costs through MY 2031 (relative to No-Action alternative, $b)					
Technology costs	7.6	2.5	7.7	11.0	19.4
Civil penalties	1.7	0.6	1.7	4.3	18.4
Total	9.3	3.1	9.3	15.3	37.9
Civil penalties as share of total	18%	19%	18%	28%	49%

Table VI-14: Compliance and Cost Summary – Light Trucks – No ZEV Alternative

Baseline

	PC2LT002	PC1LT3	PC2LT4	PC3LT5	PC6LT8
Compliance shortfalls in MY 2031 (of 19 total fleets)					
Number of manufacturers	7	10	11	13	16
Total costs through MY 2031 (relative to No-Action alternative, $b)					
Technology costs	15.6	33.3	36.0	40.7	40.4
Civil penalties	1.7	11.8	19.9	29.5	66.3
Total	17.2	45.1	55.8	70.3	106.6
Civil penalties as share of total	10%	26%	36%	42%	62%

Similar to the reference baseline, the No ZEV alternative baseline demonstrates increased civil penalties and more fleet shortfalls with higher stringency alternatives. For example, Table VI–14 shows similar rapid increases percentage of regulatory costs for light trucks as alternative increase in stringency, jumping from 10 percent for PC2LT002 to 26 percent for PC1LT3 and rising to 62 percent for PC6LT8. Like the reference baseline, the number of manufacturers facing shortfalls similarly rises as alternatives increase in stringency. Another example, Table VI–13 shows the trends in results for the No ZEV alternative baseline. The number of manufacturers facing shortfalls and the percentage of regulatory costs represented by civil penalties rapidly increase for the highest stringency scenarios considered, PC3LT5 and PC6LT8, such that at the highest stringency 49 percent of the regulatory cost is attributed to penalties and approximately three quarters of the 19 manufacturers are facing shortfalls.

- Sales and employment responses—as discussed above, sales and employment responses have historically been key to NHTSA's understanding of economic practicability.

The Alliance stated that ''The projected $3,000 average price increase over today's vehicles is likely to decrease sales and increase the average age of vehicles on our roads.'' [1098] The America First Policy Institute also referred to NHTSA's estimated costs and stated that ''Raising the upfront costs of vehicles is regressive policy; it increasingly places vehicle purchases out of financial reach for the American people and disadvantages lower-income consumers. The estimated potential savings on vehicle operation are thus irrelevant for those who would be unable to purchase a vehicle in the first

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[1098] The Alliance, at 1.

place.'' [1099] Mitsubishi commented that rising costs attributable to the proposed standards would drive ''price-sensitive car buyers . . . to the used car market [and] older, less fuel-efficient vehicles, exactly the opposite of the intention of the CAFE program.'' [1100] Mitsubishi further stated that ''the resulting increased demand for used cars would also raise used car prices, leaving a growing segment of the U.S. population—mostly low-to-moderate income families—unable to purchase a vehicle at all.'' [1101] AFPM argued that ''As ZEV prices rise, their sales and ICEV fleet turnover will slow, reducing fuel efficiency benefits and creating a significant drag on the economy.'' [1102] U.S. Chamber of Commerce offered similar comments.[1103]

The Heritage Foundation commented that the proposed standards would cause there to be fewer new vehicle choices and that those options would be more expensive, and that therefore new vehicle sales would drop, which ''will challenge the profitability of the auto industry and lead to a loss of jobs for tens of thousands of America's autoworkers, as well as a loss of jobs'' amongst suppliers, and entail ''soaring unemployment among both consumers and workers in the auto- and related industries.'' [1104] SEMA commented that ''A large-scale transition to EVs over a truncated timeline will significantly disrupt automotive supply chains and potentially eliminate many jobs in vehicle manufacturing, parts production, and repair shops,'' including negative effects on many small businesses.[1105] In contrast, Ceres commented that their 2021 report ''found that the strongest of NHTSA's previously proposed alternatives would make U.S. automakers more globally competitive and increase auto industry jobs.'' [1106] Ceres concluded that ''Failing to adopt the strongest fuel economy standards would undermine the U.S.' efforts to create a globally competitive domestic vehicle supply chain and put [their] members' business strategies at risk.'' [1107] The Conservation Voters of South Carolina cited the same Ceres report to argue that ''Strong fuel economy standards mean more U.S. manufacturing opportunities that can provide new, well-paying, family-sustaining union manufacturing jobs.'' [1108]

While NHTSA agrees generally that changes in per-vehicle costs can affect vehicle sales and thus employment, the analysis for this final rule found that the effects were much smaller than the commenters above suggest could occur. Section 8.2.2.3 of the RIA discusses NHTSA's findings that, with the exception of PC6LT8, sales effects in the action alternatives differ from the No-Action alternative by no more than 1 percent in any given model year, with most below this value.[1109] Relatedly, Table 8–1 in Section 8.2.2.3 of the RIA shows that maximum employment effects in any year is fewer than 7,000 full time equivalent jobs added (against a backdrop of over 900,000 full time equivalent jobs industry-wide). Overall labor utilization follows the general trend of the No-Action alternative but increases very slightly over the reference baseline in all but the most stringent action alternative cases, which indicates to NHTSA that technological innovation (industry's need to build more advanced technologies in response to the standards) ultimately outweighs sales effects in the rulemaking time frame. Under the No ZEV alternative baseline, sales and labor market effects are slightly larger than in the reference baseline. This is in line with expectations, as alternative baseline costs are slightly larger than costs in the reference baseline. With the exception of PC6LT8, where sales reductions are approximately 3 percent, sales changes for all other action alternatives relative to the No-Action alternative remain below 1.5 percent. Labor market increases do not exceed 8,000 full-time equivalent jobs added over No-Action levels.[1110] Given that annual sales and employment effects represent differences of well under 2 percent for each year for every regulatory alternative, contrary to the commenters' concerns, NHTSA does not find sales or employment effects to be dispositive for economic practicability in this rulemaking.

- Uncertainty and consumer acceptance of technologies—these are considerations not accounted for expressly in our modeling analysis,[1111] but important to an assessment of economic practicability given the timeframe of this rulemaking. Consumer acceptance can involve consideration of anticipated consumer response not just to increased vehicle cost and consumer valuation of fuel economy, but also the way manufacturers may change vehicle models and vehicle sales mix in response to CAFE standards.

Many commenters stated that the proposed rule would restrict consumer choice by forcing consumers to purchase electric vehicles, because there would be no ICE vehicles available.[1112] Mitsubishi expressed concern that the proposal would require OEMs to ''prematurely phase-out some of the most affordable/cleaner ICE and hybrid vehicles and replace them with more expensive battery electric vehicles, thereby limiting consumer choice for fuel efficient and affordable vehicles.'' [1113] Heritage Foundation argued that the ICEs that could meet the standards would be ''anemic'' and ''woefully lacking in power, durability, and performance and will thus offer far less utility for America's families,'' causing a ''generational loss in consumer welfare.'' [1114] Additional commenters argued that these required BEVs would not meet consumers' diverse needs,[1115] and that consumers did not want them.[1116] The American

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[1099] America First Policy Institute, Docket No. NHTSA–2023–0022–61447, at 3.

[1100] Mitsubishi, Docket No. NHTSA–2023–0022–61637, at 10.

[1101] *Id.*

[1102] AFPM, Docket No. NHTSA–2023–0022–61911, Attachment 2, at 67.

[1103] U.S. Chamber of Commerce, Docket No. NHTSA–2023–0022–61069, at 3.

[1104] Heritage Foundation, Docket No. NHTSA–2023–0022–61952, at 7.

[1105] SEMA, Docket No. NHTSA–2023–0022–57386, at 3.

[1106] Ceres BICEP, Docket No. NHTSA–2023–0022–28667, at 1.

[1107] *Id.*

[1108] Conservation Voters of South Carolina, Docket No. NHTSA–2023–0022–27799, at 1.

[1109] NHTSA models total light duty sales differences from the regulatory baseline based on the percentage difference in the average price paid by consumers, net of any tax credits. NHTSA adjusts sales using a constant price elasticity of -0.4. NHTSA's methodology is explained in more detail in TSD Chapter 4.1.

[1110] For additional detail, see FRIA 8.2.7.

[1111] *See, e.g., Center for Auto Safety* v. *NHTSA* (CAS), 793 F.2d 1322 (D.C. Cir. 1986) (Administrator's consideration of market demand as component of economic practicability found to be reasonable).

[1112] American Consumer Institute, Docket No. NHTSA–2023–0022–50765, at 2; WPE, Docket No. NHTSA–2023–0022–52616, at 1; National Association of Manufacturers, Docket No. NHTSA–2023–0022–59203–A1, at 1; Heritage Foundation, Docket No. NHTSA–2023–0022–61952, Attachment 1, at 3; SEMA, Docket No. NHTSA–2023–0022–57386, at 2; POET, Docket No. NHTSA–2023–0022–61561, at 13; AHUA, Docket No. NHTSA–2023–0022–58180, at 3; MCGA, Docket No. NHTSA–2023–0022–58413, at 2; CEI, Docket No. NHTSA–2023–0022–61121, at 2.

[1113] Mitsubishi, Docket No. NHTSA–2023–0022–61637, at 2.

[1114] Heritage Foundation, Docket No. NHTSA–2023–0022–61952, at 6.

[1115] American Consumer Institute, at 2; Heritage Foundation, at 7.

[1116] KCGA, at 3; American Consumer Institute, Docket No. NHTSA–2023–0022–50765, Attachment 1, at 1, 7–8; CFDC *et al.,* Docket No. NHTSA–2023–0022–62242, at 16; AFPM, Docket No. NHTSA–2023–0022–61911, Attachment 2, at 52 (citing range anxiety and infrastructure limitations); CEI, Docket No. NHTSA–2023–0022–61121, at 9 (citing ''high purchase price,'' price ''volatility,'' range anxiety,

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Consumer Institute, for example, stated that ''Car companies losing money on their EV divisions is a testament to their unpopularity among the public. Several automakers are losing tens of thousands of dollars for every unit sold. One of the 'Big Three' automobile manufacturers is poised to lose billions on its electric vehicles division this year.'' [1117] CEI argued that higher vehicle prices would force ''millions'' of households to ''rely on transit'' and ''experience significant losses of personal liberty, time, convenience, economic opportunity, health, safety, and, yes, fun.'' [1118] NADA cited data from multiple surveys suggesting that consumers would not consider buying EVs or were very unlikely to buy one.[1119] Other commenters stated that more lead time was needed to make more BEVs and for more consumers to accept them.[1120]

In contrast, the States and Cities commented that the proposed standards promoted greater consumer choice, ''as consumers will have a greater array of vehicles with higher fuel economy, including plug-in and mild hybrids, some of which offer advantages over internal combustion engine vehicles, such as faster vehicle acceleration, more torque, and lower maintenance costs.'' [1121] Lucid commented that research from Consumer Reports showed that fuel economy was important to many American consumers and that ''Stringent fuel economy standards are aligned with the interests of American consumers.'' [1122]

NHTSA disagrees that the proposed standards would have forced new vehicle buyers to purchase BEVs, and thus comments expressing concern about alleged lack of consumer interest in BEVs are not relevant here. CAFE standards do not and cannot require electrification. BEVs included in the reference baseline are simply those that are anticipated to exist in the world for reasons other than CAFE compliance, including but not limited to estimated consumer demand for BEVs as costs decrease over time in response to market forces. NHTSA's analysis of the effects of potential new CAFE standards is bound by the statutory constraints.

That said, NHTSA agrees with comments suggesting that improved fuel economy is beneficial to consumers, and that having an array of vehicle choices with higher fuel economy is also beneficial. While NHTSA has no authority to compel manufacturers to improve fuel economy in every single vehicle that they offer, higher average fleet fuel economy standards improve the likelihood that more vehicle models' fuel economy will improve over time. NHTSA does not believe that it is a given that improving fuel economy comes at the expense of improving other vehicle attributes appreciated by consumers, and NHTSA's analysis expressly holds vehicle performance constant when simulating the application of fuel-efficient technologies.[1123] The assumption of performance neutrality is built into the technology costs incurred in the analysis, and thus ensures the costs to maintain performance are represented when feasibility is considered. While this does not address every single vehicle attribute listed by commenters, NHTSA believes that it helps to ensure the economic practicability of the standards that NHTSA chooses.

That said, NHTSA is also aware, as cited above, that a number of manufacturers are beginning to introduce new SHEV and PHEV models, purportedly in response to consumer demand for them.[1124] NHTSA still maintains that our analysis demonstrates only *one* technological path toward compliance with potential future CAFE standards, and that there are many paths toward compliance, but it may be a relevant data point that the technological path we show includes a reliance on SHEV technology in the light truck sector, particularly pickups, similar to some product plans recently announced or already being implemented.[1125] The auto industry has a strong interest in offering vehicles that consumers will buy. Introducing new models with these technologies suggests that the industry believes that consumer demand for these technologies is robust enough to support a greater supply. The future remains uncertain, but it is possible that NHTSA's constrained analysis may not completely fail to reflect consumer preferences for vehicle technologies, if recent and planned manufacturer behavior is indicative.

Over time, NHTSA has tried different methods to account for economic practicability. NHTSA previously abandoned the ''least capable manufacturer'' approach to ensuring economic practicability, of setting standards at or near the level of the manufacturer whose fleet mix was, on average, the largest and heaviest, generally having the highest capacity (for passengers and/or cargo) and capability (in terms of ability to perform their intended function(s)) so as not to limit the availability of those types of vehicles to consumers.[1126] Economic practicability has typically focused on the capability of the industry and seeks to avoid adverse consequences such as (inter alia) a significant loss of jobs or unreasonable elimination of consumer choice. If the overarching purpose of EPCA is energy conservation, NHTSA generally believes that it is reasonable to expect that maximum feasible standards may be harder for some automakers than for others, and that they need not be keyed to the capabilities of the least capable manufacturer. NHTSA concluded in past rulemakings that keying standards to the least capable manufacturer may disincentivize innovation by rewarding laggard performance, and it could very foreseeably result in less energy conservation than an approach that looked at the abilities of the industry as a whole.

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refueling times, ''reduced cold-weather performance,'' and ''less reliability during blackouts'').

[1117] American Consumer Institute, at 7.

[1118] CEI, Docket No. NHTSA–2023–0022–61121, at 2.

[1119] NADA, Docket No. NHTSA–2023–0022–58200, at 7.

[1120] National Association of Manufacturers, at 1.

[1121] States and Cities, Docket No. NHTSA–2023–0022–61904, Attachment 2, at 30–31.

[1122] Lucid, Docket No. NHTSA–2023–0022–50594, Attachment 1, at 5.

[1123] Performance neutrality is further discussed in the Final TSD Chapter 2.3.4 and in the CAFE Analysis Autonomie Documentation.

[1124] Reuters. 2024. U.S. automakers race to build more hybrids as EV sales slow. Mar. 15, 2024. Available at: *https://www.reuters.com/business/autos-transportation/us-automakers-race-build-more-hybrids-ev-sales-slow-2024-03-15/*.

[1125] Rosevear, J. CNBC. 2023. As Ford loses billions on EVs, the company embraces hybrids. Jul. 28, 2023. Available at: *https://www.cnbc.com/2023/07/28/ford-embraces-hybrids-as-it-loses-billions-on-evs.html*; Sutton, M. Car and Driver. 2024. 2024 Toyota Tacoma Hybrid Is a Spicier Taco. Apr.23, 2024. Available at: *https://www.caranddriver.com/reviews/a60555316/2024-toyota-tacoma-hybrid-drive/*.

[1126] NHTSA has not used the ''least capable manufacturer'' approach since prior to the model year 2005–2007 rulemaking (68 FR 16868, Apr. 7, 2003) under the non-attribute-based (fixed) CAFE standards.

IPI commented that NHTSA's emphasis on costs, that as NHTSA notes are ''likely overstate[d],'' resembles the rejected ''least capable manufacturer approach.'' IPI stated that ''This rejection is reasonable,'' as NHTSA had explained in the NPRM, and that therefore ''costs should not be a decisive barrier to adopting more stringent standards.'' [1127] NHTSA agrees that for purposes of the final rule, estimated per-vehicle costs are not a decisive barrier to adopting more stringent standards, because costs for a number of alternatives are well within limits which NHTSA has previously considered economically practicable. However, estimated civil penalties, as a subcomponent of manufacturer costs, do remain meaningful in light of the technological transition that NHTSA does not consider directly, insofar as manufacturers state that they divert resources from that transition, even though NHTSA assumes that manufacturers eventually recoup those costs by passing them forward to consumers. NHTSA thus concludes that, for purposes of this final rule, the threshold of economic practicability may be much lower in terms of estimated shortfalls than NHTSA tentatively concluded could be practicable in the NPRM.

NHTSA recognizes that this approach to economic practicability may appear to be focusing on the least capable manufacturers, but as industry and other commenters noted, civil penalties do not reduce fuel use or emissions, and thus do not serve the overarching purpose of EPCA. They merely consume resources that could otherwise be better spent elsewhere. NHTSA has also sought to account for economic practicability by applying marginal benefit-cost analysis since the first rulemakings establishing attribute-based standards, considering both overall societal impacts and overall consumer impacts. Whether the standards maximize net benefits has thus been a relevant, albeit not dispositive, factor in the past for NHTSA's consideration of economic practicability. E.O. 12866 states that agencies should ''select, in choosing among alternative regulatory approaches, those approaches that maximize net benefits . . .'' As the E.O. further recognizes, agencies, including NHTSA, must acknowledge that the modeling of net benefits does not capture all considerations relevant to economic practicability, and moreover that the uncertainty of input assumptions makes perfect foresight impossible. As in past rulemakings, NHTSA has considered our estimates of net societal impacts, net consumer impacts, and other related elements in the consideration of economic practicability. We emphasize, however, that it is well within our discretion to deviate from the level at which modeled net benefits appear to be maximized if we conclude that the level would not represent the maximum feasible level for future CAFE standards, given all relevant and statutorily-directed considerations, as well as unquantifiable benefits.[1128] Economic practicability is complex, and like the other factors must be considered in the context of the overall balancing and EPCA's overarching purpose of energy conservation.

The Renewable Fuels Association *et al.* commented that the passenger car standards for both the PC1LT3 and PC2LT4 alternatives were beyond economically practicable, because NHTSA's analysis showed that they resulted in net costs for both society and for consumers.[1129] The commenters stated that NHTSA had explained in the NPRM that it had the authority to deviate from the point at which net benefits were maximized if other statutory considerations made it appropriate to do so, but the commenters asserted that the fuel savings associated with those alternatives were ''not high'' and did not outweigh the costs.[1130] Institute for Energy Research and Mitsubishi offered similar comments.[1131] POET argued that because even NHTSA acknowledged that there was substantial uncertainty in its analysis, therefore NHTSA should ''only adopt standards that clearly have a net positive benefit under all its main discount rate scenarios,'' using ''conservative assumptions'' ''to avoid a rule that puts automakers into severe non-compliance.'' [1132]

In contrast, IPI argued that the net benefits of all alternatives were likely understated due to (1) ''conservative'' assumptions about the SC–GHG and discount rates, and (2) the analysis ending at calendar year 2050 rather than extending further, ''given that more stringent standards' net benefits rise quickly in later years.'' [1133]

In response, NHTSA notes that the benefit-cost landscape of the final rule is somewhat different from the NPRM analysis. While NHTSA maintains that economic practicability does not mandate that the agency choose only the alternative(s) that maximize net benefits, NHTSA agrees that passenger car and light truck standards should be independently justifiable. NHTSA also agrees that alternatives for which costs outweigh benefits should be scrutinized closely, even while NHTSA recognizes that certain benefits, especially related to climate effects, remain uncaptured by our analysis. Regarding the timeframe of the analysis, NHTSA emphasizes the fact that model-year accounting for benefits and costs focuses on effects over the lifetime of the light duty vehicles affected by the rulemaking. The fleet of remaining vehicles declines over time, and the analysis extends beyond calendar year 2050. For example, a model year 2031 vehicle accrues benefits and costs through calendar year 2070, though only approximately 2 percent of these vehicles remain in the fleet.[1134]

To examine the benefit-cost landscape and results more closely, Table VI–15 reports social benefits and costs for passenger cars and light trucks separately, along with the total net benefits for the two fleets combined. Though the preferred alternative does not maximize net benefits across the two fleets, it is the only alternative in which net benefits are positive for both passenger cars and light trucks.

[1127] IPI, NHTSA–2023–0022–60485, at 10.

[1128] Even E.O. 12866 acknowledges that ''Nothing in this order shall be construed as displacing the agencies' authorities or responsibilities, as authorized by law.'' E.O. 12866, Sec. 9.

[1129] Renewable Fuels Association *et al.,* Docket No. NHTSA–2023–0022–1652, at 14–15; RFA *et al.* 1, Docket No. NHTSA–2023–0022–57720, at 4.

[1130] *Id.*

[1131] Institute for Energy Research, Docket No. NHTSA–2023–0022–63063, at 2; Mitsubishi, Docket No. NHTSA–2023–0022–61637, at 3.

[1132] POET, Docket No. NHTSA–2023–0022–61561, at 13.

[1133] IPI, Docket No. NHTSA–2023–0022–60485, at 11.

[1134] See RIA 8.2.4 for an illustration of model-year accounting of benefits and costs, reported by calendar year.

This holds at both the 3 percent social discount rate and a more conservative 7 percent discount rate, as shown in Table VI–16.

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Table VI-15: Incremental Benefits and Costs Over the Lifetimes of Total Fleet Produced Through MY 2031 (3% Social Discount Rate, 2% SC-GHG Discount Rate, $2021 billions)[1135]

	PC2LT002	PC1LT3	PC2LT4	PC3LT5	PC6LT8
Passenger Cars					
Social Costs					
Technology Costs	5.5	1.5	4.5	7.4	13.5
Non-Technology Costs[1136]	1.7	10.4	14.1	17.6	22.5
Total Social Costs	7.2	11.9	18.6	25.0	36.0
Social Benefits					
Reduced Fuel Costs	8.0	2.4	4.3	6.0	10.9
Non-Fuel Private Benefits[1137]	2.1	1.3	2.0	2.7	4.6
Total Private Benefits	10.1	3.7	6.3	8.7	15.5
Non-Climate External Benefits	0.6	0.0	0.0	0.0	0.1
Reduced Climate Damages	10.2	3.2	5.5	7.5	13.5
Total Social Benefits	20.9	6.8	11.8	16.3	29.1
Net Social Benefits	**13.7**	**-5.0**	**-6.8**	**-8.7**	**-6.9**
Light Trucks					
Social Costs					
Technology Costs	8.5	15.4	21.1	24.7	29.6
Non-Technology Costs	8.7	4.5	7.4	10.5	15.2
Total Social Costs	17.3	19.9	28.5	35.1	44.7
Social Benefits					
Reduced Fuel Costs	13.4	29.9	36.4	38.8	41.0
Non-Fuel Private Benefits	3.5	7.4	9.2	10.1	10.9
Total Private Benefits	16.9	37.3	45.6	48.8	52.0
Non-Climate External Benefits	1.2	2.2	2.5	2.6	2.6
Reduced Climate Damages	20.7	39.5	47.3	50.1	53.0
Total Social Benefits	38.8	79.0	95.4	101.5	107.5
Net Social Benefits	**21.5**	**59.0**	**66.9**	**66.4**	**62.7**
Net Social Benefits (PC + LT)	**35.2**	**54.0**	**60.1**	**57.7**	**55.8**

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[1135] Values may not add exactly due to rounding.

[1136] Includes safety costs, congestion and noise costs, and loss in fuel tax revenue.

[1137] Includes benefits from rebound VMT and less frequent refueling.

Table VI-16: Incremental Benefits and Costs Over the Lifetimes of Total Fleet Produced Through MY 2031 (7% Social Discount Rate, 2% SC-GHG Discount Rate, $2021 billions)

	PC2LT002	PC1LT3	PC2LT4	PC3LT5	PC6LT8
Passenger Cars					
Total Social Costs	5.1	7.2	11.5	15.6	23.5
Total Social Benefits	16.2	5.2	9.0	12.3	22.0
Net Social Benefits	**11.1**	**-2.0**	**-2.6**	**-3.3**	**-1.5**
Light Truck					
Total Social Costs	11.1	13.9	19.5	23.8	30.3
Total Social Benefits	30.8	61.6	74.2	78.9	83.4
Net Social Benefits	**19.7**	**47.7**	**54.6**	**55.1**	**53.1**
Net Social Benefits (PC + LT)	**30.8**	**45.8**	**52.1**	**51.9**	**51.6**

Net benefits for PC2LT002 remain positive due in part to differences in fleet and travel behavior projected by the CAFE Model. That is, when stringencies increase at a faster rate for light trucks, as in alternatives PC1LT3 through PC6LT8, passenger cars see significantly more use and are kept in service longer. The resulting increase in costs (*e.g.,* additional fuel use from more driving) offsets some portion of benefits (*e.g.,* reduced fuel use from higher fuel economy). The rate of improved benefits for passenger cars is also limited by the technology feasibility issues discussed in the section above. The PC2LT002 stringency manages to strike a favorable balance of this effect.

To examine this effect in more detail, observe the levels of incremental private benefits and non-technology costs for alternatives PC1LT3 through PC6LT8 relative to PC2LT002 in Table VI–15. The majority of this difference is an artifact of the interaction between passenger car and light truck fleets in instances where car and truck stringencies increase at different rates. For instance, where light truck stringency increases faster than passenger car stringency (*e.g.,* PC2LT4), light truck vehicle costs increase more than passenger car costs. This reduces light truck sales, and hence total light truck non-rebound VMT.[1138] The sales effect, coupled with the model's aggregate non-rebound VMT constraint, increases passenger car VMT. This change in mileage affects a number of benefit-cost categories. Some of the categories for which mileage is a central input include congestion and noise costs, safety costs, fuel savings benefits, and emissions reductions. With increased passenger car mileage, congestion and noise costs and safety costs all increase relative to the No-Action alternative. Some fuel savings benefits for the passenger car fleet are offset by increased travel relative to the No-Action alternative; even if industry-wide fuel economy levels rise, increased vehicle use can suppress fuel savings benefits as overall fuel savings is the product of the two metrics. Emissions reductions for the passenger car fleet are offset in a similar manner. In the case of PC2LT002, costs, sales, and VMT do not see the same VMT shift as the other action alternatives. For passenger cars, this produces lower non-technology costs and avoids suppressing some portion of projected fuel cost savings and emissions reductions. The higher costs and partially-offset benefits of PC1LT3 through PC6LT8 combine to produce negative net social benefits for the passenger car fleet in these alternatives. Conversely, the absence of VMT shifts between fleets in the case of PC2LT002 allow net social benefits to remain positive.[1139]

Consumer benefits and costs produce a slightly different picture. For the passenger car fleet, per-vehicle fuel savings exceed regulatory cost in both PC2LT002 (by $191 in model year 2031) and PC1LT3 (by $132 in model year 2031). For the light truck fleet, this difference remains positive for PC2LT002, PC1LT3, and PC2LT4.

[1138] The CAFE Model's non-rebound VMT constraint operates on a fleet-wide basis and does not hold VMT fixed within regulatory class.

[1139] For all of the reasons discussed in the TSD and FRIA, NHTSA believes that the CAFE model's treatment of passenger car and light truck VMT and fleet share behavior are reasonable representations of market behavior, and that the benefit-cost values that result are a plausible result of the modeled compliance pathways. NHTSA also ran a sensitivity case with the fleet share adjustment disabled, which showed that PC2LT002 remains the alternative with the highest net benefits for passenger cars. *See* Chapter 9 of the FRIA for full results.

Table VI-17: Fuel Cost Savings and Regulatory Costs, $2021 Per Vehicle, 3% Social Discount Rate, Passenger Car

	2027	2028	2029	2030	2031
PC2LT002					
Fuel savings	213	289	423	486	548
Regulatory cost	135	227	398	413	357
Net	78	62	25	73	191
PC1LT3					
Fuel savings	116	164	254	273	300
Regulatory cost	72	134	212	220	168
Net	44	30	42	53	132
PC2LT4					
Fuel savings	164	250	390	456	503
Regulatory cost	127	278	471	506	450
Net	36	-27	-81	-51	53
PC3LT5					
Fuel savings	184	304	492	623	758
Regulatory cost	246	455	724	812	848
Net	-62	-152	-232	-189	-90
PC6LT8					
Fuel savings	191	520	824	1,084	1,321
Regulatory cost	537	1,072	1,650	2,036	2,303
Net	-346	-552	-826	-952	-982

Table VI-18: Per-Vehicle Fuel Cost Savings and Regulatory Costs, 3% Social Discount Rate, Light Truck

	2027	2028	2029	2030	2031
PC2LT002					
Fuel savings	149	250	327	398	690
Regulatory cost	126	176	224	272	409
Net	24	74	103	127	281
PC1LT3					
Fuel savings	299	523	697	856	1,165
Regulatory cost	226	410	523	643	835
Net	73	113	174	212	329
PC2LT4					
Fuel savings	346	647	846	1,087	1,434
Regulatory cost	276	538	694	1,039	1,277
Net	70	109	152	48	156
PC3LT5					
Fuel savings	363	684	904	1,179	1,591
Regulatory cost	330	646	862	1,395	1,730
Net	33	38	43	-216	-139
PC6LT8					
Fuel savings	346	714	997	1,295	1,703
Regulatory cost	541	1,096	1,581	2,472	3,065
Net	-195	-382	-583	-1,177	-1,362

From these tables, it is clear that consumers who purchase passenger cars stand to save the most from the PC2LT002 standards, according to the statutorily-constrained analysis, and that the more stringent alternatives would result in net consumer costs, as identified by some commenters. For light truck purchasers, PC1LT3 represents slightly higher net fuel savings, but PC2LT002 is only about $50 less per vehicle.

Under the No ZEV alternative baseline analysis, results are fairly similar, as shown:

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Table VI-19: Incremental Benefits and Costs Over the Lifetimes of Total Fleet Produced Through MY 2031 (3% Social Discount Rate, 2% SC-GHG Discount Rate, $2021 billions), No ZEV Alternative Baseline[1140]

	PC2LT002	PC1LT3	PC2LT4	PC3LT5	PC6LT8
Passenger Cars					
Social Costs					
Technology Costs	5.8	1.9	5.9	8.5	15.0
Non-Technology Costs[1141]	4.6	20.1	20.6	24.6	25.6
Total Social Costs	10.5	22.0	26.5	33.1	40.6
Social Benefits					
Reduced Fuel Costs	10.3	2.0	6.2	7.8	11.6
Non-Fuel Private Benefits[1142]	3.2	1.9	3.1	3.8	5.1
Total Private Benefits	13.5	3.9	9.3	11.6	16.8
Non-Climate External Benefits	0.4	-0.4	-0.2	-0.2	-0.1
Reduced Climate Damages	11.8	2.0	7.0	9.0	13.7
Total Social Benefits	25.7	5.5	16.1	20.5	30.3
Net Social Benefits	**15.3**	**-16.5**	**-10.4**	**-12.6**	**-10.2**
Light Trucks					
Social Costs					
Technology Costs	12.0	25.7	27.8	31.5	31.3
Non-Technology Costs	12.9	4.8	8.6	9.6	16.6
Total Social Costs	24.9	30.6	36.4	41.1	47.8
Social Benefits					
Reduced Fuel Costs	19.5	40.2	41.5	41.7	39.1
Non-Fuel Private Benefits	5.4	9.7	10.3	10.4	10.3
Total Private Benefits	24.9	49.9	51.9	52.1	49.4
Non-Climate External Benefits	1.5	2.8	2.9	2.8	2.5
Reduced Climate Damages	28.2	52.5	54.4	54.4	51.5
Total Social Benefits	54.6	105.2	109.1	109.3	103.4
Net Social Benefits	**29.7**	**74.7**	**72.7**	**68.2**	**55.6**
Net Social Benefits (PC + LT)	**44.9**	**58.2**	**62.3**	**55.6**	**45.4**

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[1140] Values may not add exactly due to rounding.

[1141] Includes safety costs, congestion and noise costs, and loss in fuel tax revenue.

[1142] Includes benefits from rebound VMT and less frequent refueling.

Table VI-20: Incremental Benefits and Costs Over the Lifetimes of Total Fleet Produced Through MY 2031 (7% Social Discount Rate, 2% SC-GHG Discount Rate, $2021 billions), No ZEV Alternative Baseline

	PC2LT002	PC1LT3	PC2LT4	PC3LT5	PC6LT8
Passenger Cars					
Total Social Costs	6.9	12.9	16.2	20.6	26.6
Total Social Benefits	19.6	3.9	12.0	15.2	22.6
Net Social Benefits	**12.7**	**-9.0**	**-4.2**	**-5.3**	**-4.0**
Light Truck					
Total Social Costs	15.7	21.3	24.9	28.2	32.3
Total Social Benefits	42.8	81.9	84.9	85.0	80.4
Net Social Benefits	**27.1**	**60.7**	**60.0**	**56.9**	**48.0**
Net Social Benefits (PC + LT)	**39.8**	**51.7**	**55.7**	**51.6**	**44.0**

For light trucks, net benefits under the No ZEV alternative baseline analysis peak at PC1LT3, while for passenger cars, net benefits operate generally the same way under the No ZEV alternative baseline analysis as under the reference baseline analysis, where net benefits are only positive for PC2LT002, and remain positive due in part to differences in fleet and travel behavior projected by the CAFE Model, as discussed above.

Consumer benefits and costs produce a slightly different picture. For the passenger car fleet, per-vehicle fuel savings exceed regulatory cost in both PC2LT002 (by $375 in model year 2031) and PC1LT3 (by $191 in model year 2031). For the light truck fleet, this difference remains positive for PC2LT002, and PC1LT3. In these regulatory alternatives under the No ZEV alternative baseline, regulatory costs increase slightly over those in the reference baseline but this is outweighed by an increase in fuel savings.

Table VI-21: Fuel Cost Savings and Regulatory Costs, $2021 Per Vehicle, 3% Social Discount Rate, Passenger Car, No ZEV Alternative Baseline

	2027	2028	2029	2030	2031
PC2LT002					
Fuel savings	74	272	552	792	1,005
Regulatory cost	-26	146	454	594	629
Net	100	125	98	198	375
PC1LT3					
Fuel savings	49	150	298	448	575
Regulatory cost	10	108	263	379	384
Net	39	41	34	69	191
PC2LT4					
Fuel savings	67	267	512	751	967
Regulatory cost	62	311	628	799	884
Net	5	-44	-117	-48	83
PC3LT5					
Fuel savings	107	342	638	917	1,189
Regulatory cost	148	469	925	1,168	1,407
Net	-41	-127	-287	-251	-217
PC6LT8					
Fuel savings	107	558	896	1,229	1,531
Regulatory cost	518	1,244	1,912	2,443	2,948
Net	-410	-686	-1,016	-1,215	-1,416

Table VI-22: Per-Vehicle Fuel Cost Savings and Regulatory Costs, 3% Social Discount Rate, Light Truck, No ZEV Alternative Baseline

	2027	2028	2029	2030	2031
PC2LT002					
Fuel savings	150	269	450	693	1,098
Regulatory cost	130	194	305	443	677
Net	20	75	144	250	421
PC1LT3					
Fuel savings	307	642	895	1,203	1,657
Regulatory cost	288	540	722	1,239	1,520
Net	20	102	173	-36	137
PC2LT4					
Fuel savings	303	655	964	1,293	1,761
Regulatory cost	328	649	907	1,496	1,871
Net	-25	6	57	-203	-110
PC3LT5					
Fuel savings	290	644	969	1,304	1,772
Regulatory cost	440	818	1,138	1,893	2,331
Net	-150	-173	-169	-589	-560
PC6LT8					
Fuel savings	258	614	937	1,268	1,737
Regulatory cost	590	1,226	1,799	2,890	3,722
Net	-332	-612	-863	-1,621	-1,985

From these tables, under the No ZEV alternative baseline analysis as under the reference baseline analysis, it is clear that consumers who purchase passenger cars stand to save the most from the PC2LT002 standards, according to the statutorily-constrained analysis, and that the more stringent alternatives would result in net consumer costs, as identified by some commenters. For light truck purchasers, PC2LT002 also saves consumers the most under the No ZEV alternative baseline analysis. Given the passenger car results and the closeness of the light truck results, NHTSA concludes that PC2LT002 would be most directly beneficial for consumers according to the constrained analysis.

(3) The Effect of Other Motor Vehicle Standards of the Government on Fuel Economy

''The effect of other motor vehicle standards of the Government on fuel economy'' involves analysis of the effects of compliance with emission, safety, noise, or damageability standards on fuel economy capability, and thus on the industry's ability to meet a given level of CAFE standards. In many past CAFE rulemakings, NHTSA has said that it considers the adverse effects of other motor vehicle standards on fuel economy. It said so because, from the CAFE program's earliest years until recently, compliance with these other types of standards has had a negative effect on fuel economy.[1143] For example, safety standards that have the effect of increasing vehicle weight thereby lower fuel economy capability (because a heavier vehicle must work harder to travel the same distance, and in working harder, consumes more energy), thus decreasing the level of average fuel economy that NHTSA can determine to be feasible. NHTSA notes that nothing about the Federal Motor Vehicle Safety Standards (FMVSS) would be altered or inhibited by this CAFE/HDPUV standards rule. NHTSA has also accounted for Federal Tier 3 and California LEV III criteria pollutant standards within its estimates of technology effectiveness in prior rules and in this final rule.[1144]

In other cases, the effect of other motor vehicle standards of the Government on fuel economy may be neutral, or positive. Since the Obama Administration, NHTSA has considered the GHG standards set by EPA as ''other motor vehicle standards of the Government.'' NHTSA received many comments about considering EPA's GHG standards. BMW commented that ''coordination between NHTSA and EPA during the rulemaking process is critical'' and stated further that in light of differences in governing statutes, NHTSA and EPA ''have historically recognized and accounted for these differences in the standard setting process.'' [1145] Jaguar stated that ''while there has always been a degree of misalignment between NHTSA CAFE and EPA GHG regulations due to differences in their treatment of BEVs,'' NHTSA had gone to great lengths in the model years 2024–2026 CAFE rule to minimize those differences, and needed

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[1143] 43 FR 63184, 63188 (Dec. 15, 1977). *See also* 42 FR 33534, 33537 (Jun. 30, 1977).

[1144] For most ICE vehicles on the road today, the majority of vehicle-based NO_X, NMOG, and CO emissions occur during ''cold-start,'' before the three-way catalyst has reached higher exhaust temperatures (*e.g.,* approximately 300°C), at which point it is able to convert (through oxidation and reduction reactions) those emissions into less harmful derivatives. By limiting the amount of those emissions, vehicle-level smog standards require the catalyst to be brought to temperature rapidly, so modern vehicles employ cold-start strategies that intentionally release fuel energy into the engine exhaust to heat the catalyst to the right temperature as quickly as possible. The additional fuel that must be used to heat the catalyst is typically referred to as a ''cold-start penalty,'' meaning that the vehicle's fuel economy (over a test cycle) is reduced because the fuel consumed to heat the catalyst did not go toward the goal of moving the vehicle forward. The Autonomie work employed to develop technology effectiveness estimates for this final rule accounts for cold-start penalties, as discussed in the Chapter ''Cold-start Penalty'' of the ''CAFE Analysis Autonomie Documentation''.

[1145] BMW, Docket No. NHTSA–2023–0022–58614, at 1.

to make a similar proof for the current final rule.[1146] Jaguar further argued that ''If NHTSA cannot consider that BEVs are required to meet their proposed CAFE standards, NHTSA should consider that significant levels of electrification are needed to meet the EPA targets.'' [1147] The Alliance also argued that NHTSA's proposed standards were ''serious[ly] misalign[ed]'' with EPA's proposed standards, given, among other things, DOE's proposal to revise the PEF value.[1148] The Alliance further stated that EPA's proposed standards were ''neither reasonable nor achievable'' and needed to be less stringent, and that NHTSA's CAFE standards ''should also be modified commensurately.'' [1149]

Subaru stated that ''regulatory alignment'' between NHTSA, EPA, DOE (with the PEF value revision) and CARB was crucial, because ''Regulations that impose differing requirements for the same vehicle add costs, without consumer benefit, and divert resources that could otherwise be used toward meeting the Administration's electrification goals.'' [1150] Subaru added that ''If any automaker can comply with one set of standards, they should not be in jeopardy of paying penalties toward another agency's efficiency program,'' and suggested that the DOE PEF value revision made that more likely under NHTSA's proposal.[1151] GM commented that not only should manufacturers be able to comply with both standards without paying penalties in CAFE space, but that they should also be able to comply ''without . . . restricting product, or purchasing credits,'' and that NHTSA, EPA, and CARB needed ''to base their analyses of industry compliance . . . on the same level of EV deployment and ICE criteria pollutant and efficiency improvement.'' [1152] Nissan stated that the combination of EPA, NHTSA, DOE, and CARB regulations ''create a complicated and unachievable landscape for the automotive industry in the proposed timeframe.'' [1153] AHUA made a similar point and added that it complicates the landscape for related industries (like electricity generation/infrastructure and mining/minerals processing) as well, concluding that ''It makes it harder to make favorable assumptions on how quickly changes can be made in the market for EV chargers and in other markets that must perform well to facilitate marketplace acceptance of EVs and otherwise increase fuel economy as proposed in these efforts.'' [1154]

Volkswagen commented that EPA's rule was ''the leading rule'' and that NHTSA's proposal ''fails to align'' and needed to ''harmonize[ ] to the finalized EPA GHG regulation,'' [1155] or if not, that NHTSA accept compliance with EPA's standard in lieu of compliance with NHTSA's standard.[1156] POET similarly commented that NHTSA should finalize standards ''no more stringent than what correlates to fuel economy equivalence under a corrected EPA light-duty vehicle GHG rule.'' [1157] ANHE commented that NHTSA's standards were not strong enough and needed to be aligned with EPA's proposal to ensure benefits to lung health due to less-polluting vehicles.[1158] The Colorado State Agencies also commented that NHTSA's standards needed to be aligned with EPA's to ''avoid any backsliding'' as well as ''a scenario in which OEMs are forced to divert investment away from transportation electrification.'' [1159] Wisconsin DNR requested that NHTSA coordinate with EPA on additional standards for ozone and $PM_{2.5}$.[1160]

MEMA commented that NHTSA should abandon a separate rulemaking and ''jointly collaborate with EPA in writing one final rule,'' and that ''Joint regulatory action will also allow EPA to fill in the gaps in NHTSA's congressional authority regarding EVs.'' [1161] Consumer Reports also encouraged NHTSA to ''work with EPA to ensure consistency between the levels of stringency in each specific model year.'' [1162] MECA commented that NHTSA and EPA had long issued joint rules, and given that the agencies had issued separate proposals, NHTSA needed to ''spend additional effort to document in the final rule how the regulations are aligned and where they are not aligned.'' [1163] Specifically, MECA requested that ''NHTSA analyze the impact of separate regulations, particularly on compliance flexibility and the potential for . . . fuel economy penalties to be used as a compliance mechanism,'' and ''clearly articulate'' the effect of the revised DOE PEF value on CAFE compliance.[1164] GM similarly argued that NHTSA's analysis needed to ''include how the modeled NHTSA-, EPA-, and CARB-regulated fleets comply with all regulations with a consistent level of EVs and ICE improvement,'' both ''on an industry-wide basis'' and ''for each manufacturer individually.'' [1165]

CEI agreed that NHTSA and EPA conducting separate rulemakings was problematic, stating that it ''undermined key premises'' of *Massachusetts* v. *EPA* because the agencies now seek to ''ban ICE vehicles'' rather than to issue ''CAFE and GHG standards of approximately equal stringency.'' [1166]

[1146] Jaguar, Docket No. NHTSA–2023–0022–57296, at 5.

[1147] *Id.* at 6.

[1148] The Alliance, Docket No. NHTSA–2023–0022–60652, Attachment 2, at 2.

[1149] *Id.* at 4. National Association of Manufacturers offered similar comments, Docket No. NHTSA–2023–0022–59203–A1, at 2; Kia offered similar comments, Docket No. NHTSA–2023–0022–58542–A1, at 5–6; NADA offered similar comments, Docket No. NHTSA–2023–0033–58200, at 12.

[1150] Subaru, Docket No. NHTSA–2023–0022–58655, at 2. Ford offered similar comments, Docket No. NHTSA–2023–0022–60837, at 1; Jaguar offered similar comments, Docket No. NHTSA–2023–0022–57296, at 5; MECA offered similar comments, Docket No. NHTSA–2023–0022–63053, at 4; NADA offered similar comments, Docket No. NHTSA–2023–0022–58200, at 12; GM offered similar comments, Docket No. NHTSA–2023–0022–60686, at 4; Mitsubishi offered similar comments, Docket No. NHTSA–2023–0022–61637, at 2.

[1151] *Id.;* Kia offered similar comments, Docket No. NHTSA–2023–0022–58542–A1, at 2–3; Jaguar offered similar comments, Docket No. NHTSA–2023–0022–57296, at 6; Ford offered similar comments, Docket No. NHTSA–2023–0022–60837, at 3; Mitsubishi offered similar comments, Docket No. NHTSA–2023–0022–61637, at 2; Stellantis offered similar comments, Docket No. NHTSA–2023–0022–61107, at 3.

[1152] GM, Docket No. NHTSA–2023–0022–60686, at 4.

[1153] Nissan, Docket No. NHTSA–2023–0022–60696, at 1. BMW offered similar comments, Docket No. NHTSA–2023–0022–58614, at 1.

[1154] AHUA, Docket No. NHTSA–2023–0022–58180, at 6.

[1155] Jaguar made similar comments, at 6; AHUA also offered similar comments, Docket No. NHTSA–2023–0022–58180, at 3; Toyota offered similar comments, Docket No. NHTSA–2023–0022–61131, at 2.

[1156] Volkswagen, Docket No. NHTSA–2023–0022–58702, at 1, 3. U.S. Chamber of Commerce offered similar comments, Docket No. NHTSA–2023–0022–61069, at 2; Hyundai offered similar comments, Docket No. NHTSA–2023–0022–51701, at 2–3; NADA offered similar comments, Docket No. NHTSA–2023–0022–58200, at 12. Volkswagen also requested, if NHTSA took a ''deemed to comply'' approach, that NHTSA allow compliance ''reporting requirements [to] be streamlined.'' Volkswagen, at 3.

[1157] POET, Docket No. NHTSA–2023–0022–61561, at 10.

[1158] ANHE, Docket No. NHTSA–2023–0022–27781, at 1.

[1159] Colorado State Agencies, Docket No. NHTSA–2023–0022–41652, at 2.

[1160] Wisconsin DNR, Docket No. NHTSA–2023–0022–21431, at 2. NHTSA has no authority under EPCA/EISA or any other statute to issue standards for criteria pollutants, so this comment will not be addressed further.

[1161] MEMA, Docket No. NHTSA–2023–0022–59204–A1, at 2.

[1162] Consumer Reports, Docket No. NHTSA–2023–0022–61098, at 17.

[1163] MECA, Docket No. NHTSA–2023–0022–63053, at 3.

[1164] *Id.* at 4.

[1165] GM, Docket No. NHTSA–2023–0022–60686, at 4.

[1166] CEI, Docket No. NHTSA–2023–0022–61121, at 2. West Virginia Attorney General's Office offered similar comments, Docket No. NHTSA–2023–0022–63056, at 2.

CEI argued that EPA and NHTSA's standards were inconsistent in two ways: first, that EPA's standards were more stringent overall, and second, that NHTSA's standards were more stringent for ICE vehicles.[1167] As a result, CEI stated, manufacturers who could comply with EPA's standards but not with NHTSA's would be compelled ''to withdraw from the ICE vehicle market . . . in order to simplify and reduce overall compliance burdens.'' [1168] CEI further stated that NHTSA had not shown in the NPRM what CO_2 targets would correspond to the proposed CAFE standards, unlike in the model years 2024–2026 final rule, and argued that it was ''backwards'' for NHTSA to suggest that its proposed standards ''complement and align with EPA's'' because ''The EPA's standards increasingly clash and misalign with NHTSA's.'' [1169] The Heritage Foundation argued that NHTSA's efforts to ''force the auto industry to convert to the production of electric vehicles in violation of [its] statutory authorities'' was ''part of a unified strategy of the Biden administration, as set forth in executive orders,'' combining NHTSA, EPA, and CARB efforts.[1170]

In response, NHTSA notes that many of these comments and arguments are generally similar to those offered to the model years 2024–2026 proposal, and that the response provided by NHTSA in the model years 2024–2026 final rule largely continues to apply. NHTSA has carefully considered EPA's standards, by including the baseline (*i.e.,* through model year 2026) CO_2 standards in our analytical reference baseline for the main analysis.

In the 2012 final rule, NHTSA stated that ''[t]o the extent the GHG standards result in increases in fuel economy, they would do so almost exclusively as a result of inducing manufacturers to install the same types of technologies used by manufacturers in complying with the CAFE standards.'' [1171] NHTSA concluded in 2012 that ''no further action was needed'' because ''the agency had already considered EPA's [action] and the harmonization benefits of the National Program in developing its own [action].'' [1172] In the 2020 final rule, NHTSA reinforced that conclusion by explaining that a textual analysis of the statutory language made it clear that EPA's GHG standards are literally ''other motor vehicle standards of the Government'' because they are standards set by a Federal agency that apply to motor vehicles. NHTSA and EPA are obligated by Congress to exercise their own independent judgment in fulfilling their statutory missions, even though both agencies' regulations affect both fuel economy and CO_2 emissions. There are differences between the two agencies' programs that make NHTSA's CAFE standards and EPA's GHG standards not perfectly one-to-one (even besides the fact that EPA regulates other GHGs besides CO_2, EPA's CO_2 standards also differ from NHTSA's in a variety of ways, often because NHTSA is bound by statute to a certain aspect of CAFE regulation). NHTSA creates standards that meet our statutory obligations, including through considering EPA's standards as other motor vehicle standards of the Government.[1173] Specifically, NHTSA has considered EPA's standards through model year 2026 for this final rule by including the baseline GHG standards in our analytical reference baseline for the main analysis. Because the EPA and NHTSA programs were developed in coordination, and stringency decisions were made in coordination, NHTSA has not incorporated EPA's CO_2 standards for model years 2027–2032 as part of the analytical reference baseline for this final rule's main analysis. The fact that EPA finalized its rule before NHTSA is an artifact of circumstance only. NHTSA recognizes, however, that the CAFE standards thus sit alongside EPA's light-duty vehicle multipollutant emission standards that were issued in March. NHTSA also notes that any electric vehicles deployed to comply with EPA's standards will count towards real-world compliance with these fuel economy standards. In this final rule, NHTSA's goal has been to establish regulations that achieve energy conservation per its statutory mandate and consistent with its statutory constraints, and that work in harmony with EPA's regulations addressing air pollution. NHTSA believes that these statutory mandates can be met while ensuring that manufacturers have the flexibility they need to achieve cost-effective compliance.

NHTSA is aware that when multiple agencies regulate concurrently in the same general space, different regulations may be binding for different regulated entities at different times. Many commenters requested that NHTSA set standards low enough so that, among the CAFE, CO_2, and California regulations, the CAFE standards were never the binding regulation. NHTSA explained in the model years 2024–2026 final rule that NHTSA and EPA had explained in the 2012 final rule that depending on each manufacturer's chosen compliance path, there could be situations in which the relative difficulty of each agency's standards varied. To quote the 2012 final rule again,

> Several manufacturers commented on this point and suggested that this meant that the standards were not aligned, because NHTSA's standards might be more stringent in some years than EPA's. This reflects a misunderstanding of the agencies' purpose. The agencies have sought to craft harmonized standards such that manufacturers may build a single fleet of vehicles to meet both agencies' requirements. That is the case with these final standards. *Manufacturers will have to plan their compliance strategies considering both the NHTSA standards and the EPA standards and assure that they are in compliance with both, but they can still build a single fleet of vehicles to accomplish that goal.*'' [1174] (emphasis added)

As explained in the model years 2024–2026 final rule, even in 2012, the agencies anticipated the possibility of this situation and explained that regardless of which agency's standards are binding given a manufacturer's chosen compliance path, manufacturers will still have to choose a path that complies with both standards—and in doing so, will still be able to build a single fleet of vehicles, even if they must be slightly more strategic in how they do so. This remains the case with this final rule.

In requesting that NHTSA set CAFE standards that account precisely for each difference between the programs and ensure that CAFE standards are never more stringent than EPA's, never require any payment of civil penalties for any manufacturer, etc., commenters appear to be asking NHTSA again to define ''maximum feasible'' as ''the fuel economy level at which no manufacturer need ever apply any additional technology or spend any additional dollar beyond what EPA's standards, with their greater flexibilities, would require.'' NHTSA believes that this takes ''consideration'' of ''the effect of other motor vehicle standards of the Government'' farther than Congress intended for it to go.

NHTSA has considered EPA's standards in determining the maximum feasible CAFE standards for model years 2027–2031, as discussed above. In

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[1167] CEI, at 1.

[1168] *Id.*

[1169] *Id.* at 4.

[1170] Heritage Foundation, Docket No. NHTSA–2023–0022–61952, at 2.

[1171] 77 FR 62624, 62669 (Oct. 15, 2012).

[1172] *Id.*

[1173] *Massachusetts* v. *EPA,* 549 U.S. 497, 532 (2007) (''[T]here is no reason to think that the two agencies cannot both administer their obligations and yet avoid inconsistency.'').

[1174] 77 FR at 63054–55 (Oct. 15, 2012).

response to comments, NHTSA conducted a side study in which we analyzed simultaneous compliance with EPA's recently finalized CO_2 standards and the regulatory alternatives considered here.[1175] This analysis confirms that if industry reaches compliance with EPA's standards, then compliance with NHTSA final standards is feasible. NHTSA has coordinated its standards with EPA's where doing so was consistent with NHTSA's separate statutory direction. NHTSA disagrees that harmonization can only ever be achieved at the very cheapest level, or that this would be consistent with NHTSA's statutory mandate.

Industry commenters discussed at length their concerns with managing simultaneous compliance with NHTSA's standards while also making the technological transition that NHTSA cannot consider, just as they did in their comments to the model years 2024–2026 proposal. NHTSA recognizes that the difference in the current rulemaking is that the transition that NHTSA cannot consider directly is likely closer, and the urgency of needing all available resources and capital for that transition—resources and capital investments that NHTSA *can* consider, because they are dollars and not miles per gallon—is greater at the current time. Given that, NHTSA has accounted for the significant investments needed by manufacturers to meet EPA's standards, and has reduced CAFE stringency from the proposal accordingly, as will be discussed more in Section VI.D below. As the final standards show, it is possible for NHTSA to account for EPA's program without the agencies needing to conduct a single joint rulemaking, and without NHTSA being obliged to prove, as some commenters requested, that exactly the same technology for every single vehicle for every single manufacturer will result in compliance with all applicable standards. Manufacturers are sophisticated enterprises well-accustomed to managing compliance with multiple regulatory regimes, particularly in this space. The reduced stringency of the final standards should address their concerns.

With regard to the comments requesting that NHTSA accept compliance with EPA standards in lieu of compliance with CAFE standards, NHTSA does not believe that this would be consistent with the intent of ''the effect of other motor vehicle standards of the Government on fuel economy'' provision. Congress would not have set that provision as one factor among four for NHTSA to consider if it intended for it to control absolutely—instead, NHTSA and courts have long held that all factors must be considered together. Moreover, Congress delegated to DOT (and DOT delegated to NHTSA) decision-making authority for the CAFE standards program. The Supreme Court said in *Massachusetts* v. *EPA* that because ''DOT sets mileage standards in no way licenses EPA to shirk its environmental responsibilities. EPA has been charged with protecting the public's 'health' and 'welfare,' 42 U.S.C. 7521(a)(1), a statutory obligation wholly independent of DOT's mandate to promote energy efficiency. See Energy Policy and Conservation Act, § 2(5), 89 Stat. 874, 42 U.S.C. 6201(5). The two obligations may overlap, but there is no reason to think the two agencies cannot both administer their obligations and yet avoid inconsistency.'' The converse must necessarily be true—the fact that EPA sets GHG standards in no way licenses NHTSA to shirk its energy conservation responsibilities. Unless and until Congress changes EPCA/EISA, NHTSA is bound to continue exercising its own independent judgment and setting CAFE standards and to do so consistent with statutory directives. Part of setting CAFE standards is considering EPA's GHG standards and other motor vehicle standards of the Government and how those affect manufacturers' ability to comply with potential future CAFE standards, but that is only one inquiry among several in determining what levels of CAFE standards would be maximum feasible.

Additionally, nothing in EPCA or EISA suggests that compliance with GHG standards would be an acceptable basis for CAFE compliance. The calculation provisions in 49 U.S.C. 32904 are explicit. The compliance provisions in 49 U.S.C. 32912 state that automakers must comply with applicable *fuel economy standards,* and failure to do so is a failure to comply. Emissions standards are not fuel economy standards. NHTSA does not agree that a ''deemed to comply'' option is consistent with statute, nor that it is necessary for coordination with and consideration of those other standards.

With regard to the comments suggesting that NHTSA, EPA, California, and the rest of the Federal government are somehow colluding to force a transition from ICE to BEV technology, NHTSA reiterates that 49 U.S.C. 32902(h) bars NHTSA from setting standards that require alternative fuel vehicle technology.

With regard to state standards, as for the NPRM analysis, NHTSA considered and accounted for the impacts of anticipated manufacturer compliance with California's ACC I and ACT programs (and their adoption, where relevant, by the Section 177 states), incorporating them into the reference baseline No-Action Alternative as other regulatory requirements foreseeably applicable to automakers during the rulemaking time frame. NHTSA continues not to model other state-level emission standards, as discussed in the 2022 final rule.[1176]

API commented that NHTSA was prohibited from considering the California ACC and ACT programs in setting standards, because ''The term 'the Government' clearly is a reference to the federal government and cannot reasonably be construed as including state or local governments''; because even if it was reasonable to construe the term as including state and local governments, NHTSA ''is still barred from considering BEVs,'' because any EPA grant of a CAA waiver does not federalize those standards, and because those standards are preempted by EPCA.[1177] API stated that ''NHTSA's refusal to engage on these issues here is facially arbitrary and capricious.'' [1178]

NHTSA continues to disagree that it is necessary for NHTSA to determine definitively whether these regulatory requirements are or are not other motor vehicle standards of the Government (in effect, whether they became ''federalized'' when EPA granted the CAA preemption waiver for ACC I and ACT), because whether they are or not, it is still appropriate to include these requirements in the regulatory reference baseline because the automakers have repeatedly stated their intent to comply with those requirements during the rulemaking time frame. For the same reason, NHTSA included additional electric vehicles in the reference baseline—which would be consistent with ACC II, which has not been granted a waiver—because the automakers have similarly stated their intention to deploy electric vehicles at the modeled level independent of whether ACC II is granted a waiver and independent of the existence of NHTSA's standards. If manufacturers are operating as though they plan to comply with ACC I and ACT and deploy additional electric vehicles beyond that level, then that assumption is therefore relevant to understanding the state of the world absent any further regulatory action by NHTSA. With regard to whether the

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[1175] Side Study Memo to Docket.

[1176] *See* 87 FR at 25982 (May 2, 2022).

[1177] API, Docket No. NHTSA–2023–0022–60234, Attachment 1, at 6–7.

[1178] *Id.* at 7.

California standards are preempted under EPCA, NHTSA is not a court and thus does not have authority to make such determinations with the force of law, no matter how much commenters may wish us to do so. Further, as discussed above and below, NHTSA addressed uncertainty about the level of penetration of electric vehicles into the reference baseline fleet by developing an alternative baseline, No ZEV, and assessing the final standards against that baseline.

Some commenters also argued that NHTSA should consider the CAFE standards in the context of other Federal rules and programs. Absolute Energy commented that ''CAFE is not the only tool'' for addressing ''fuel efficiency, energy security, and decarbonization,'' and NHTSA should consider the role of CAFE given the existence of the Renewable Fuel Standard (RFS) and various tax credits and grant programs that encourage renewable fuels production.[1179] West Virginia Attorney General's office stated that by ''considering EVs as the chief compliance option'' for CAFE standards, ''NHTSA's analysis is at odds with promoting renewable fuels,'' and suggested that this created a conflict of laws.[1180] POET offered similar comments and added that ''NHTSA should expand incentives for biofuels under the CAFE program to further promote energy security.'' [1181]

In response, NHTSA agrees that CAFE is not the only tool for addressing fuel efficiency, energy security, and decarbonization. However, since CAFE compliance is measured on EPA's test cycle with a defined test fuel, and since NHTSA does not have authority to require in-use compliance, programs like the RFS and other programs that encourage biofuels production cannot factor into NHTSA's consideration. The test cycle (and the off-cycle program, which does not include alternative fuels) is NHTSA's entire world for purposes of the CAFE program. To the extent that some commenters believe there is a conflict between the RFS and the CAFE program, it has existed for decades and Congress has had multiple opportunities to address it, but has not done so. This may be evidence that the programs do not conflict but instead aim to solve similar problems with different approaches.

(4) The Need of the U.S. To Conserve Energy

NHTSA has consistently interpreted ''the need of the United States to conserve energy'' to mean ''the consumer cost, national balance of payments, environmental, and foreign policy implications of our need for large quantities of petroleum, especially imported petroleum.'' [1182] The following sections discuss each of these elements, relevant comments, and NHTSA's responses, in more detail.

(a) Consumer Costs and Fuel Prices

Fuel for vehicles costs money for vehicle owners and operators, so all else equal, consumers benefit from vehicles that need less fuel to perform the same amount of work. Future fuel prices are a critical input into the economic analysis of potential CAFE standards because they determine the value of fuel savings both to new vehicle buyers and to society; the amount of fuel economy that the new vehicle market is likely to demand in the absence of regulatory action; and they inform NHTSA about the ''consumer cost . . . of our need for large quantities of petroleum.'' For this final rule, NHTSA relied on fuel price projections from the EIA AEO for 2023, updating them from the AEO 2022 version used for the proposal. Federal Government agencies generally use EIA's price projections in their assessment of future energy-related policies.

Raising fuel economy standards can reduce consumer costs on fuel—this has long been a major focus of the CAFE program and was one of the driving considerations for Congress in establishing the CAFE program originally. Over time, as average VMT has increased and more and more Americans have come to live farther and farther from their workplaces and activities, fuel costs have become even more important. Even when gasoline prices, for example, are relatively low, they can still add up quickly for consumers whose daily commute measures in hours, like many Americans in economically disadvantaged and historically underserved communities. When vehicles can go farther on a gallon of gasoline, consumers save money, and for lower-income consumers the savings may represent a larger percentage of their income and overall expenditures than for more-advantaged consumers. Of course, when fuel prices spike, lower-income consumers suffer disproportionately. Thus, clearly, the need of the United States to conserve energy is well-served by helping consumers save money at the gas pump.

NHTSA and the DOT are committed to improving equity in transportation. Helping economically disadvantaged and historically underserved Americans save money on fuel and get where they need to go is an important piece of this puzzle, and it also improves energy conservation, thus implementing Congress' intent in EPCA. All of the action alternatives considered in this final rule improve fuel economy over time as compared to the reference baseline standards, with the most stringent alternatives saving consumers the most on fuel costs.

The States and Cities agreed that increasing fuel economy will save consumers money and also further EPCA's energy conservation goals.[1183] NESCAUM agreed that consumers would save more money under the strictest alternatives, stating that saving money on fuel was particularly important for consumers with long commutes, such as those in rural areas and economically disadvantaged and historically underserved communities.[1184] NESCAUM emphasized that lower income consumers benefit most from reductions in fuel costs and are most vulnerable to fuel cost price spikes.[1185] IPL and Chispa LCV offered similar comments.[1186] NHTSA appreciates these comments.

NHTSA also notes that, in many previous CAFE rulemakings, discussions of fuel prices have always been intended to reflect the price of motor gasoline. However, a growing set of vehicle offerings that rely in part, or entirely, on electricity suggests that gasoline prices are no longer the only fuel prices relevant to evaluations of the effects of different possible CAFE standards. In the analysis supporting this final rule, NHTSA considers the energy consumption from the entire on-road fleet, which already contains a number of plug-in hybrid and fully electric vehicles that are part of the fleet independent of CAFE standards.[1187]

[1179] Absolute Energy, Docket No. NHTSA–2023–0022–50902, at 2. CAE offered similar comments, Docket No. NHTSA–2023–0022–61599, at 3.

[1180] West Virginia Attorney General's Office, Docket No. NHTSA–2023–0022–63056, at 5–6.

[1181] POET, Docket No. NHTSA–2023–0022–61651, at 9.

[1182] *See, e.g.,* 42 FR 63184, 63188 (Dec. 15, 1977); 77 FR 62624, 62669 (Oct. 15, 2012).

[1183] States and Cities, Docket No. NHTSA–2022–0075–0033–0035, at 25–26.

[1184] NESCAUM, Docket No. NHTSA–2023–0022–57714, at 3.

[1185] *Id.*

[1186] IPL, Docket No. NHTSA–2023–0022–49058, at 1–2; Chispa LCV, Docket No. NHTSA–2023–0022–28014, at 1.

[1187] Higher CAFE standards encourage manufacturers to improve fuel economy; at the same time, manufacturers will foreseeably seek to continue to maximize profit, and to the extent that plug-in hybrids and fully-electric vehicles are cost-effective to build and desired by the market, manufacturers may well build more of these

While the current and projected national average electricity price is and is expected to remain significantly higher than that of gasoline, on an energy equivalent basis ($/MMBtu),[1188] electric motors convert energy into propulsion much more efficiently than ICEs. This means that, even though the energy-equivalent prices of electricity are higher, electric vehicles still produce fuel savings for their owners. As the reliance on electricity grows in the LD fleet, NHTSA will continue to monitor the trends in electricity prices and their implications, if any, for CAFE standards.

(b) National Balance of Payments

NHTSA has consistently included consideration of the ''national balance of payments'' as part of the need of the U.S. to conserve energy because of concerns that importing large amounts of oil created a significant wealth transfer to oil-exporting countries and left the U.S. economically vulnerable.[1189] According to EIA, the net U.S. petroleum trade value deficit peaked in 2008, but it has fallen over the past decade as volumes of U.S. petroleum exports increased to record-high levels and imports decreased.[1190] The 2020 net U.S. petroleum trade value deficit was $3 billion, the smallest on record, partially because of less consumption amid COVID mitigation efforts.[1191] In 2020 and 2021, annual total petroleum net imports were actually negative, the first years since at least 1949. For petroleum that was imported in 2023, 52 percent came from Canada, 11 percent came from Mexico, 5 percent came from Saudi Arabia, 4 percent came from Iraq and 3 percent came from Brazil.[1192] The States and Cities agreed that finalizing the proposal would improve the U.S. balance of payments and protect consumers from global price shocks, and added that ''NHTSA could strengthen its analysis by acknowledging that the U.S. consumed more petroleum than it produced in 2022, and that the U.S. remained a net crude oil importer in 2022, importing about 6.28 million barrels per day of crude oil and exporting about 3.58 million barrels per day.'' [1193] NHTSA appreciates the comment.

While transportation demand is expected to continue to increase as the economy recovers from the pandemic, it is foreseeable that the trend of trade in consumer goods and services continuing to dominate the national balance of payments, as compared to petroleum, will continue during the rulemaking time frame.[1194] Regardless, the U.S. does continue to rely on oil imports. Moreover, because the oil market is global in nature, the U.S. is still subject to price volatility, as recent global events have demonstrated.[1195] NHTSA recognizes that reducing the vulnerability of the U.S. to possible oil price shocks remains important. This final rule aims to improve fleet-wide fuel efficiency and to help reduce the amount of petroleum consumed in the U.S., and therefore aims to improve this part of the U.S. balance of payments as well as to protect consumers from global price shocks.

(c) Environmental Implications

Higher fleet fuel economy reduces U.S. emissions of CO_2 as well as various other pollutants by reducing the amount of oil that is produced and refined for the U.S. vehicle fleet but can also potentially increase emissions by reducing the cost of driving, which can result in increased vehicle miles traveled (*i.e.,* the rebound effect). Thus, the net effect of more stringent CAFE standards on emissions of each pollutant depends on the relative magnitudes of its reduced emissions in fuel refining and distribution and any increases in emissions from increased vehicle use. Fuel savings from CAFE standards also result in lower emissions of CO_2, the main GHG emitted as a result of refining, distribution, and use of transportation fuels.

NHTSA has considered environmental issues, both within the context of EPCA and the context of NEPA, in making decisions about the setting of standards since the earliest days of the CAFE program. As courts of appeal have noted in three decisions stretching over the last 20 years,[1196] NHTSA defined ''the need of the United States to conserve energy'' in the late 1970s as including, among other things, environmental implications. In 1988, NHTSA included climate change considerations in its CAFE notices and prepared its first environmental assessment addressing that subject.[1197] It cited concerns about climate change as one of the reasons for limiting the extent of its reduction of the CAFE standard for model year 1989 passenger cars.[1198]

NHTSA also considers EJ issues as part of the environmental considerations under the need of the United States to conserve energy, as described in the Final Environmental Impact Statement for this rulemaking.'' [1199] The affected environment for EJ is nationwide, with a focus on areas that could contain communities with EJ concerns who are most exposed to the environmental and health effects of oil production, distribution, and consumption, or the impacts of climate change. This includes areas where oil production and refining occur, areas near roadways, coastal flood-prone areas, and urban areas that are subject to the heat island effect.

Numerous studies have found that some environmental hazards are more prevalent in areas where minority and low-income populations represent a higher proportion of the population compared with the general population. In terms of effects due to criteria pollutants and air toxics emissions, the body of scientific literature points to disproportionate representation of minority and low-income populations in proximity to a range of industrial, manufacturing, and hazardous waste facilities that are stationary sources of air pollution, although results of individual studies may vary. While the

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vehicles, even though NHTSA does not expressly consider them as a compliance option when we are determining maximum feasible CAFE stringency. Due to forces other than CAFE standards, however, we do expect continued growth in electrification technologies (and we reflect those forces in the analytical baseline).

[1188] See AEO. 2023. Table 3: Energy Prices by Sector and Source. Available at: *https://www.eia.gov/outlooks/aeo/data/browser/#/?id=3-AEO2023&cases=ref2023&sourcekey=0.* (Accessed: Mar. 22, 2024).

[1189] For the earliest discussion of this topic, *see* 42 FR 63184, 63192 (Dec. 15, 1977).

[1190] EIA. 2021. Today in Energy: U.S. Energy Trade Lowers the Overall 2020 U.S. Trade Deficit for the First Time on Record. Last revised: Sept. 22, 2021. Available at *https://www.eia.gov/todayinenergy/detail.php?id=49656#.* (Accessed: Feb. 27, 2024).

[1191] EIA. 2022. Oil and Petroleum Products Explained, Oil Imports and Exports. Last revised: Nov. 2, 2022. Available at: *https://www.eia.gov/energyexplained/oil-and-petroleum-products/imports-and-exports.php.* (Accessed Feb. 27, 2024).

[1192] EIA. Frequently Asked Questions (FAQs): How much petroleum does the United States import and export? Last revised: March 29, 2024. Available at: *https://www.eia.gov/tools/faqs/faq.php?id=727&t=6.* (Accessed April 16, 2024).

[1193] States and Cities, Docket No. NHTSA–2022–0075–0033–0011, at 26.

[1194] EIA, Oil and Petroleum Products Explained, Oil Imports and Exports.

[1195] *See, e.g.,* FRED (St. Louis Federal Reserve) Blog, ''The Ukraine War's effects on US commodity prices,'' Oct. 26, 2023, *available at https://fredblog.stlouisfed.org/2023/10/the-ukraine-wars-effects-on-us-commodity-prices/* (last accessed May 23. 2024).

[1196] *CAS,* 793 F.2d 1322, 1325 n. 12 (D.C. Cir. 1986); *Public Citizen,* 848 F. 2d 256, 262–63 n. 27 (D.C. Cir. 1988) (noting that ''NHTSA itself has interpreted the factors it must consider in setting CAFE standards as including environmental effects''); CBD, 538 F.3d 1172 (9th Cir. 2007).

[1197] 53 FR 33080, 33096 (Aug. 29, 1988).

[1198] 63 FR 39275, 39302 (Oct. 6, 1988).

[1199] DOT. 2021. Actions to Address Environmental Justice in Minority Populations and Low-Income Populations. Order 5610.2(c).

scientific literature specific to oil refineries is limited, disproportionate exposure of minority and low-income populations to air pollution from oil refineries is suggested by other broader studies of racial and socioeconomic disparities in proximity to industrial facilities generally. Studies have also consistently demonstrated a disproportionate prevalence of minority and low-income populations living near mobile sources of pollutants (such as roadways) and therefore are exposed to higher concentrations of criteria air pollutants in multiple locations across the United States. Lower-positioned socioeconomic groups are also generally more exposed to air pollution, and thus generally more vulnerable to effects of exposure.

In terms of exposure to climate change risks, the literature suggests that across all climate risks, low-income communities, some communities of color, and those facing discrimination are disproportionately affected by climate events. Communities overburdened by poor environmental quality experience increased climate risk due to a combination of sensitivity and exposure. Urban populations experiencing inequities and health issues have greater susceptibility to climate change, including substantial temperature increases. Some communities of color facing cumulative exposure to multiple pollutants also live in areas prone to climate risk. Indigenous peoples in the United States face increased health disparities that cause increased sensitivity to extreme heat and air pollution.

Available information indicates that climate impacts disproportionately affect communities with environmental justice concerns in part because of socioeconomic circumstances, including location of lower-income housing, histories of discrimination, and inequity can be contributing factors. Furthermore, high temperatures can exacerbate poor air quality, further compounding the risk to overburdened communities. Finally, health-related sensitivities in low-income and minority populations increase risk of damaging impacts from poor air quality under climate change, underscoring the potential benefits of improving air quality to communities overburdened by poor environmental quality. Chapter 7 of the EIS discusses EJ issues in more detail.

In the EIS, Chapters 3 through 5 discuss the connections between oil production, distribution, and consumption, and their health and environmental impacts. Electricity production and distribution also have health and environmental impacts, discussed in those chapters as well.

All of the action alternatives in this final rule reduce carbon dioxide emissions and, thus, the effects of climate change, over time as compared to the reference baseline. Under the No ZEV alternative baseline analysis as compared to the reference baseline analysis, CO_2 emissions (and thus climate change effects) are reduced by similar magnitudes under the different action alternatives, because while the No ZEV alternative baseline starts at a higher CO_2 level than the reference baseline, the action alternatives under the No ZEV alternative baseline analysis reduce CO_2 by more than the action alternatives under the reference baseline analysis. Criteria pollutant and air toxic emissions are also all reduced over time compared to both the reference baseline analysis and the No ZEV alternative baseline analysis, with marginal changes occurring in early years and becoming more pronounced in later years as more new vehicles subject to the standards enter the fleet and the electricity grid shifts fuel sources. FRIA Chapter 8 discusses modeled standard-setting air quality and climate effects in more detail, while Chapters 4 and 5 of the EIS discuss the unrestricted modeling results in more detail.

As discussed above, while our analysis suggests that the majority of LDVs will continue to be powered by ICEs in the near- to mid-term under all regulatory alternatives, greater electrification in the mid- to longer-term is foreseeable. While NHTSA is prohibited from considering the fuel economy of EVs in determining maximum feasible CAFE standards, EVs (which appear both in NHTSA's reference baseline and which may be produced in model years following the period of regulation as an indirect effect of more stringent standards, or in response to other non-NHTSA standards, or in response to tax incentives and other government incentives, or in response to market demand) produce few to zero combustion-based emissions. As a result, electrification contributes meaningfully to the decarbonization of the transportation sector, in addition to having additional environmental, health, and economic development benefits, although these benefits may not yet be equally distributed across society. They also present new environmental (and social) questions, like the consequences of upstream electricity production, minerals extraction for battery components, and ability to charge an EV. The upstream environmental effects of extraction and refining for petroleum are well-recognized; minerals extraction and refining can also have significant environmental impacts. NHTSA's EIS discusses these and other effects (such as production and end-of-life issues) in more detail in Chapters 3 and 6, and NHTSA will continue to monitor these issues going forward insofar as CAFE standards may end up causing increased electrification levels even if NHTSA does not consider electrification in setting those standards, because NHTSA does not control what technologies manufacturers use to meet those standards, and because NHTSA is required to consider the environmental effects of its standards under NEPA.

NHTSA carefully considered the environmental effects of this rulemaking, both quantitative and qualitative, as discussed in the EIS and in Sections VI.C and VI.D of this preamble.

Comments on climate effects associated with the proposal varied. The States and Cities commented that consideration of the environmental effects of the regulatory alternatives as set forth in the Draft EIS supported more stringent standards, because reducing GHG emissions is necessary to stave off the worst effects of climate change, and because more stringent standards will also help to reduce criteria pollutant emissions.[1200] That commenter also argued that NHTSA had likely understated the climate benefits of stricter standards by using a SC–GHG value that ''does not fully capture the harms from climate change . . . particularly in terms of unquantified climate damages (such as damages caused by more frequent and intense wildfires and loss of cultural and historical resources, neither of which are accounted for in the SC–GHG) and its utilization of overly high discount rates.'' [1201] An individual citizen commented that NHTSA should finalize the strictest possible standards even though they do not contribute greatly to overall emissions because ''all emissions count.'' [1202]

In contrast, CEI commented that ''climate change is not a crisis, and the global warming mitigation achieved by the proposed CAFE standards would be orders of magnitude smaller than scientists can detect or identify.'' [1203] CEA argued that NHTSA should not be considering climate effects in

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[1200] States and Cities, Docket No. NHTSA–2022–0075–0033–0012, at 8, 26–28.

[1201] *Id.* at 33.

[1202] Roselie Bright, Docket No. NHTSA–2022–0075–0030–0007, at 1.

[1203] CEI, Docket No. NHTSA–2023–0022–61121, at 2, 10.

determining maximum feasible standards, because to do so contradicted *Massachusetts* v. *EPA,* which states that EPA's and NHTSA's obligations are ''wholly independent'' from one another.[1204] The commenter further argued that ''Case law holding NHTSA may consider climate change is therefore in serious conflict with Supreme Court precedent.'' [1205]

NHTSA agrees that stricter standards should, in theory, reduce emissions further, although NHTSA recognizes the possibility of situations under which intended emission reductions might not be fully achieved. For example, on the supply side of the market, if standards were too strict, companies might choose to pay civil penalties instead of complying with the standards. On the demand side of the market, vehicle prices associated with standards that are too strict could potentially lead some consumers to forego new vehicle purchases, perhaps choosing less fuel efficient alternatives and thus dampening the intended emissions reductions. Climate effects of potential new CAFE standards may appear small in absolute terms, as suggested by CEI, but they are quantifiable, as shown in the FRIA, and they do contribute meaningfully to mitigating the worst effects of climate change, as part of a suite of actions taken by the U.S. and the international community. With regard to the comments from CEA, NHTSA reiterates that the overarching purpose of the CAFE standards is energy conservation. Improving fuel economy generally reduces carbon dioxide emissions, because basic principles of chemistry explain that consuming less carbon-based fuel to do the same amount of work results in less carbon dioxide being released per amount of work (in this case, a vehicle traveling a mile). Thus, reducing climate-related emissions is an effect of improving fuel economy, even if it is not the overarching purpose of improving fuel economy. Another effect of improving fuel economy is that consumers can travel the same distance for less money spent on fuel. If NHTSA took the comment literally, NHTSA would be compelled to consider only gallons of fuel use avoided, rather than the dollars that would otherwise be spent on those gallons. NHTSA disagrees that it would be appropriate to circumscribe its effects analysis to such a degree. It should also be clear at this point that EPA and NHTSA are each capable of executing their statutory obligations independently.

On environmental justice, SELC and NESCAUM commented that exposure to smog disproportionately affects communities with environmental justice concerns, and that stricter CAFE standards would reduce these effects.[1206] Lucid commented that finalizing PC6LT8 would not only reduce on-road emissions but also significantly reduce emissions associated with petroleum extraction and distribution.[1207] Climate Hawks commented that all vehicles should have exhaust pipes on the left side, so that pedestrians on sidewalks did not have to breathe in emissions.[1208]

NHTSA agrees that environmental justice concerns are significant and that stricter CAFE standards reduce effects on communities with environmental justice concerns in many ways. NHTSA does not have authority to regulate the location of exhaust pipes on a vehicle, and so is unable to respond further to Climate Hawks on the point raised in the comment.

(d) Foreign Policy Implications

U.S. consumption and imports of petroleum products impose costs on the domestic economy that are not reflected in the market price for crude petroleum or in the prices paid by consumers for petroleum products such as gasoline. These costs include (1) higher prices for petroleum products resulting from the effect of U.S. oil demand on world oil prices; (2) the risk of disruptions to the U.S. economy, and the effects of those disruptions on consumers, caused by sudden increases in the global price of oil and its resulting impact of fuel prices faced by U.S. consumers; (3) expenses for maintaining the Strategic Petroleum Reserve (SPR) to provide a response option should a disruption in commercial oil supplies threaten the U.S. economy, to allow the U.S. to meet part of its International Energy Agency obligation to maintain emergency oil stocks, and to provide a national defense fuel reserve; and (4) the threat of significant economic disruption, and the underlying effect on U.S. foreign policy, if an oil-exporting country threatens the United States and uses, as part of its threat, its power to upend the U.S. economy. Reducing U.S. consumption of crude oil or refined petroleum products (by reducing motor fuel use) can reduce these external costs.

In addition, a 2006 report by the Council on Foreign Relations identified six foreign policy costs that it said arose from U.S. consumption of imported oil: (1) The adverse effect that significant disruptions in oil supply will have for political and economic conditions in the U.S. and other importing countries; (2) the fears that the current international system is unable to secure oil supplies when oil is seemingly scarce and oil prices are high; (3) political realignment from dependence on imported oil that limits U.S. alliances and partnerships; (4) the flexibility that oil revenues give oil-exporting countries to adopt policies that are contrary to U.S. interests and values; (5) an undermining of sound governance by the revenues from oil and gas exports in oil-exporting countries; and (6) an increased U.S. military presence in the Middle East that results from the strategic interest associated with oil consumption.

CAFE standards over the last few decades have conserved significant quantities of oil, and the petroleum intensity of the U.S. fleet has decreased significantly. Continuing to improve energy conservation and reduce U.S. oil consumption by raising CAFE standards further has the potential to continue to help with all of these considerations. Even if the energy security picture has changed since the 1970s, due in no small part to the achievements of the CAFE program itself in increasing fleetwide fuel economy, energy security in the petroleum consumption context remains extremely important. Congress' original concern with energy security was the impact of supply shocks on American consumers in the event that the U.S.'s foreign policy objectives lead to conflicts with oil-producing nations or that global events more generally lead to fuel disruptions. Moreover, oil is produced, refined, and sold in a global marketplace, so events that impact it anywhere, impact it everywhere. The world is dealing with these effects currently. Oil prices have fluctuated dramatically in recent years and reached over $100/barrel in 2022. A motor vehicle fleet with greater fuel economy is better able to absorb increased fuel costs, particularly in the short-term, without those costs leading to a broader economic crisis, as had occurred in the 1973 and 1979 oil crises. Ensuring that the U.S. fleet is positioned to take advantage of cost-effective technology innovations will allow the U.S. to continue to base its international activities on foreign policy objectives

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[1204] CEA, Docket No. NHTSA–2023–0022–61918, at 28.

[1205] *Id.*

[1206] SELC, Docket No. NHTSA–2023–0022–60224, at 5, 6; NESCAUM, Docket No. NHTSA–2023–0022–57714, at 3. MPCA agency offered similar comments, Docket No. NHTSA–2023–0022–60666, at 2; IPL offered similar comments, Docket No. NHTSA–2023–0022–49058, at 2.

[1207] Lucid, Docket No. –2023–0022–50594, at 6.

[1208] Climate Hawks, Docket No. NHTSA–2023–0022–61094, at 854.

that are not limited, at least not completely, by petroleum issues. Further, when U.S. oil consumption is linked to the globalized and tightly interconnected oil market, as it is now, the only means of reducing the exposure of U.S. consumers to global oil shocks is to reduce their oil consumption and the overall oil intensity of the U.S. economy. Thus, the reduction in oil consumption driven by fuel economy standards creates an energy security benefit.

This benefit is the original purpose behind the CAFE standards. Oil prices are inherently volatile, in part because geopolitical risk affects prices. International conflicts, sanctions, civil conflicts targeting oil production infrastructure, pandemic-related economic upheaval, cartels, all of these have had dramatic and sudden effects on oil prices in recent years. For all of these reasons, energy security remains quite relevant for NHTSA in determining maximum feasible CAFE standards.[1209] There are extremely important energy security benefits associated with raising CAFE stringency that are not discussed in the TSD Chapter 6.2.4, and which are difficult to quantify, but have weighed importantly for NHTSA in developing the standards in this final rule.

The States and Cities agreed with NHTSA that energy security in the petroleum consumption context remains extremely important, and encouraged NHTSA to choose a more stringent alternative than the proposed standards, citing potential benefits in terms of reducing military spending and reducing revenue to regimes potentially hostile to U.S. interests.[1210] In contrast, America First Policy Institute commented that improving energy security and reducing costs for consumers can be more expeditiously done using other policies.[1211] While NHTSA agrees that more stringent standards must directionally improve foreign policy benefits, it has long been difficult to quantify these effects precisely due to numerous confounding factors. NHTSA thus considers these effects from a mostly qualitative perspective. In response to whether other policies might more “expeditiously” improve energy security and reduce consumer costs, even if that were true, Congress requires NHTSA to continue setting standards, and when setting standards, to set maximum feasible standards.[1212]

Heritage Foundation stated that U.S. oil and gas reserves are plentiful and that a “proper consideration of the ‘need of the U.S. to conserve energy’ should result in standards becoming less stringent.”[1213] This could be true if oil were not a global commodity. Oil produced in the U.S. is not necessarily consumed in the U.S., and its price is tied to global oil prices (and their fluctuations due to world events). CAFE standards are intended to insulate against external risks *given* the U.S. participation in global markets, and thus, strong CAFE standards continue to be helpful in this regard.

A number of commenters expressed concern that “essentially mandating electric vehicles” would create non-petroleum-related energy security issues, associated with production of critical minerals for BEVs in parts of the world that are neither consistently reliable nor friendly to U.S. interests.[1214] Related comments argued that the U.S. could not itself produce sufficient critical minerals to supply the volumes of BEVs that would be needed to meet the standards.[1215] Other related comments argued that the U.S. *could* produce sufficient petroleum, but could *not* produce sufficient critical minerals, and that requiring vehicles to be BEVs amounted to creating an energy security issue where there would otherwise be none.[1216] Various commenters said that NHTSA's commitment to “monitoring” these issues was insufficient, and that NHTSA was required to analyze these energy security risks from electrification (including, among other things, critical minerals and electric grid capacity and cybersecurity) expressly.[1217]

In the model years 2024–2026 final rule, NHTSA responded to similar comments by explaining that NHTSA is prohibited from considering the fuel economy of electric vehicles in determining maximum feasible standards, and that the agency did not believe that the question was truly ripe, given expected concentrations of electrified vehicles in the-then rulemaking time frame. For the current rulemaking, due to the proliferation of electrified vehicles in the reference baseline, it is harder to say that the question is not ripe, and if NHTSA considers the resources necessary for the technological transition (without considering the fuel economy of BEVs or the full fuel economy of PHEVs) in evaluating economic practicability, then it is logical also to be informed about energy security effects of these vehicles (without considering their fuel economy) in evaluating the need of the U.S. to conserve energy. That said, there is a difference between being informed about something, and taking responsibility for it. As long as NHTSA is statutorily prohibited from considering the fuel economy of BEVs and the full fuel economy of PHEVs, NHTSA continues to disagree that it is *required* to account in its determination for energy security effects that CAFE regulations are prohibited from causing. This discussion is part of NHTSA's ongoing commitment to monitoring these issues. Commenters may wish for NHTSA to take responsibility for which the agency does not have authority, but NHTSA continues to believe that remaining informed is the best and most reasonable course of action in this area.

As discussed in Chapter 6.2.4 of the TSD, as the number of electric vehicles on the road continues to increase, NHTSA agrees that the issue of energy security is likely to expand to encompass the United States' ability to supply the material necessary to build these vehicles and the additional electricity necessary to power their use. Nearly all electricity in the United States is generated through the conversion of domestic energy sources and thus its supply does not raise security concerns, although commenters did express some concern with grid resilience and cybersecurity. NHTSA is

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[1209] TSD Chapter 6.2.4 also discusses emerging energy security considerations associated with vehicle electrification, but NHTSA only considers these effects for decision-making purposes within the framework of the statutory restrictions applicable to NHTSA's determination of maximum feasible CAFE standards.

[1210] States and Cities, Docket No. NHTSA–2022–0075–0033–0012, at 27.

[1211] America First Policy Institute, Docket No. NHTSA–2023–0022–61447, at 7.

[1212] 49 U.S.C. 32902.

[1213] Heritage Foundation, Docket No. NHTSA–2023–0022–61952, at 10.

[1214] Valero, Docket No. NHTSA–2023–0022–58547, Appendix A, at 7; Absolute Energy, Docket No. NHTSA–2023–0022–50902, at 2; Heritage Foundation, Docket No. NHTSA–2023–0022–61952, at 9; NATSO *et al.,* Docket No. NHTSA–2023–0022–61070, at 12; West Virginia Attorney General's Office, Docket No. NHTSA–2023–0022–63056, at 12–15; ACE, Docket No. NHTSA–2023–0022–60683, at 2–3; American Consumer Institute, Docket No. NHTSA–2023–0022–50765, at 6, 7.

[1215] KCGA, Docket No. NHTSA–2023–0022–59007, at 3.

[1216] Institute for Energy Research, Docket No. NHTSA–2023–0022–63063, at 3, 4.

[1217] MME, Docket No. NHTSA–2023–0022–50861, at 2; WPE, Docket No. NHTSA–2023–0022–52616, at 2; MCGA, Docket No. NHTSA–2023–0022–60208, at 3–10; RFA *et al.* 2, Docket No. NHTSA–2023–0022–41652, at 3–10 (arguing that it would be arbitrary and capricious for NHTSA not to issue a supplemental NPRM expressly analyzing and accounting for energy security risks associated with critical minerals); HCP, Docket No. NHTSA–2023–0022–59280, at 2; SIRE, Docket No. NHTSA–2023–0022–57940, at 2; Missouri Corn Growers Association, Docket No. NHTSA–2023–0022–58413, at 2; CAE, Docket No. NHTSA–2023–0022–61599, at 2; AFPM, Docket No. NHTSA–2023–0022–61911, Attachment 2, at 21; Heritage Foundation, Docket No. NHTSA–2023–0022–61952, at 10.

aware that under the Bipartisan Infrastructure Law, DOE will administer more than $62 billion for investments in energy infrastructure, including $14 billion in financial assistance to States, Tribes, utilities, and other entities who provide products and services for enhancing the reliability, resilience, and energy efficiency of the electric grid.[1218] Dozens of projects are already underway across the country.[1219] This work is ongoing and NHTSA has no reason at present to conclude that it is not being addressed, as commenters suggest. With regard to cybersecurity, if commenters mean to suggest that BEVs are at greater risk of hacking than ICEVs, NHTSA disagrees that this is the case. NHTSA's efforts on cybersecurity cover all light vehicles, as all new light vehicles are increasingly computerized.[1220] Additionally, the Joint Office of Energy and Transportation published cybersecurity procurement language to address risks when building out charging infrastructure.[1221] If commenters mean to suggest that there are cybersecurity risks associated with electric grid attacks, those would exist no matter how many BEVs or other electrified vehicles there were. DOE is also actively involved in this issue,[1222] and as before, NHTSA has no reason to think either that this is not being addressed, as commenters suggest, or that because work is ongoing, it is an inherent barrier to NHTSA's assumptions.

Besides requiring electricity generation and distribution, electric vehicles also require batteries to store and deliver that electricity. Currently, the most commonly used vehicle battery chemistries include materials that are relatively scarce or expensive, and are sourced largely from overseas sites, and/or (like any mined minerals) can pose environmental challenges during extraction and conversion to usable material, which can create security issues if environmental challenges result in political destabilization. NHTSA does not include costs or benefits related to securing sourcing of battery materials in its analysis for this final rule, just as NHTSA has not previously or here included costs or benefits associated with the energy security considerations associated with internal combustion vehicle supply chains. However, we are aware that uncertainties exist. Although robust efforts are already underway to build a secure supply chain for critical minerals that includes domestic sources as well as friendly countries, the U.S. is currently at a disadvantage with respect to domestic sources of materials (raw and processed). To combat these challenges, President Biden issued an E.O. on ''America's Supply Chains,'' aiming to strengthen the resilience of America's supply chains, including those for automotive batteries.[1223] Reports covering six sectors were developed by seven agencies within one year of issuance of the E.O. and outlined specific actions for the Federal government and Congress to take.[1224] The Biden-Harris administration also awarded $2.8 billion from the Bipartisan Infrastructure Law to support projects that develop supplies of battery-grade lithium, graphite, and nickel and invest in other battery related mineral production.[1225] Overall, the BIL appropriates $7.9 billion for the purpose of battery manufacturing, recycling, and critical minerals.[1226]

The Inflation Reduction Act calls for half of the Clean Vehicle Credit to be contingent on at least 40 percent of the value of the critical minerals in the battery having been extracted or processed in the United States or a country with a U.S. free-trade agreement, or recycled in North America. Starting in 2025, an EV cannot qualify for the clean vehicle credit if the vehicle's battery contains critical minerals that were extracted, processed, or recycled by a ''foreign entity of concern.''[1227] The Inflation Reduction Act also included an Advanced Manufacturing Production tax credit that provides taxpayers who produce certain eligible components, such as electrodes and battery arrays for BEVs, and critical minerals tax credits on a per-unit basis.[1228] These measures are intended to spur the development of more secure supply chains for critical minerals used in battery production. Additionally, since 2021, over $100 billion of investments have been announced for new or expanded U.S. facilities for recycling and upcycling, materials separation and processing, and battery component manufacturing.[1229]

The IRA also removed the $25 billion cap on the total amount of Advanced Technology Vehicle Manufacturing direct loans.[1230] These loans may be used to expand domestic production of advanced technology vehicles and their components. Finally, it established the Domestic Manufacturing Conversion Grant Program, a $2 billion cost-shared grant program to aid businesses in manufacturing for hybrid, plug-in hybrid electric, plug-in electric drive, and hydrogen fuel cell electric vehicles.[1231]

With regard to making permitting for critical minerals extraction more efficient and effective, the Biden-Harris administration has also targeted permitting reform as a legislative priority.[1232] This includes reforming mining laws to accelerate the development of domestic supplies of critical minerals. These priorities also include improving community engagement through identifying community engagement officers for permitting processes, establishing community engagement funds to expand the capacity of local governments, Tribes, or community groups to engage on Federal actions, create national maps of Federal actions being analyzed with an Environmental Impact Statement, and transferring funds to Tribal Nations to enhance engagement in National Historic Preservation Act consultations. In March 2023, the administration also released implementation guidance for permitting provisions in the BIL. This

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[1218] *https://netl.doe.gov/bilhub/grid-resilience* (last accessed Mar. 28, 2024).

[1219] *https://www.energy.gov/gdo/grid-resilience-and-innovation-partnerships-grip-program-projects* (last accessed Mar. 28, 2024).

[1220] *https://www.nhtsa.gov/research/vehicle-cybersecurity* (last accessed Mar. 28, 2024).

[1221] *See https://driveelectric.gov/news/joint-office-offers-new-cybersecurity-resource* (last accessed May 23, 2024).

[1222] *https://www.energy.gov/sites/default/files/2021/01/f82/OTT-Spotlight-on-Cybersecurity-final-01-21.pdf* (last accessed Mar. 28, 2024).

[1223] White House. 2021. Executive Order on America's Supply Chains. Available at: *https://www.whitehouse.gov/briefing-room/presidential-actions/2021/02/24/executive-order-on-americas-supply-chains/* (last accessed May 31, 2024).

[1224] White House. 2022. Executive Order on America's Supply Chains: A Year of Actions and Progress. National Security Affairs. Washington, DC. Available at: *https://www.whitehouse.gov/wp-content/uploads/2022/02/Capstone-Report-Biden.pdf* (last accessed Mar. 28, 2024).

[1225] *See https://netl.doe.gov/node/12160* (last accessed Mar. 28, 2024).

[1226] Congressional Research Service. Energy and Minerals Provisions in the Infrastructure Investment and Jobs Act (Pub. L. 117–58). CRS Report R47034. Congressional Research Service. *Available at https://crsreports.conress.gov/product/pdf/R/R47034*. (last accessed Feb. 14, 2024).

[1227] Public Law 117–169, Section 13401.

[1228] *Id.,* Section 13502.

[1229] *See* U.S. Department of Energy, 2023. Battery Supply Chain Investments. *Available at https://www.energy.gov/investments-american-made-energy* (last accessed Feb. 14, 2024).

[1230] *See https://www.energy.gov/lpo/inflation-reduction-act-2022* (last accessed Mar. 28, 2024).

[1231] *See https://www.energy.gov/mesc/domestic-manufacturing-conversion-grants* (last accessed Mar. 28, 2024).

[1232] *See* The White House, 2023, Fact Sheet: Biden-Harris Administration Outlines Priorities for Building America's Infrastructure Faster, Safer and Cleaner. *Available at https://www.whitehouse.gov/briefing-room/statements-releases/2023/05/10/fact-sheet-biden-harris-administration-outlines-priorities-for-building-americas-energy-infrastructure-faster-safer-and-cleaner/* (last accessed Mar. 28, 2024).

guidance directs agencies to, among other things: engage in early and meaningful outreach and communication with Tribal Nations, States, Territories, and Local Communities; improve responsiveness, technical assistance, and support; adequately resource agencies and use the environmental review process to improve environmental and community outcomes.[1233]

Based on all of the above, NHTSA finds that the energy security benefits of more stringent CAFE standards outweigh any potential energy security drawbacks that (1) are not the result of the CAFE standards and (2) are being actively addressed by numerous government and private sector efforts.

When considering both the reference baseline and the No ZEV alternative baseline analyses, NHTSA finds that fuel savings, national balance of payments, environmental implications, and energy security effects are all similar with reference to estimated outcomes of the different action alternatives. When alternatives are compared to either baseline, more stringent CAFE standards would generally result in more energy conserved and thus better meet the need of the United States to conserve energy.

(5) Factors That NHTSA Is Prohibited From Considering

EPCA also provides that in determining the level at which it should set CAFE standards for a particular model year, NHTSA may not consider the ability of manufacturers to take advantage of several EPCA provisions that facilitate compliance with CAFE standards and thereby reduce the costs of compliance.[1234] NHTSA cannot consider the trading, transferring, or availability of compliance credits that manufacturers earn by exceeding the CAFE standards and then use to achieve compliance in years in which their measured average fuel economy falls below the standards. NHTSA also must consider dual fueled automobiles to be operated only on gasoline or diesel fuel, and it cannot consider the possibility that manufacturers would create new dedicated alternative fueled automobiles—including battery-electric vehicles—to comply with the CAFE standards in any model year for which standards are being set. EPCA encourages the production of AFVs by specifying that their fuel economy is to be determined using a special calculation procedure; this calculation results in a more-generous fuel economy assignment for alternative-fueled vehicles compared to what they would achieve under a strict energy efficiency conversion calculation. Of course, manufacturers are free to use dedicated and dual-fueled AFVs and credits in achieving compliance with CAFE standards.

The effect of the prohibitions against considering these statutory flexibilities (like the compliance boosts for dedicated and dual-fueled alternative vehicles, and the use and availability of overcompliance credits) in setting the CAFE standards is that NHTSA cannot set standards that assume the use of these flexibilities in response to those standards—in effect, that NHTSA cannot set standards as stringent as NHTSA would if NHTSA *could* account for the availability of those flexibilities. For example, NHTSA cannot set standards based on an analysis that modeled technology pathway that includes additional BEV penetration specifically in response to more stringent CAFE standards.

In contrast, for the non-statutory fuel economy improvement value program that NHTSA developed by regulation, as explained in the proposal, NHTSA has long believed that these fuel economy adjustments are not subject to the 49 U.S.C. 32902(h) prohibition. The statute is very clear as to which flexibilities are not to be considered in determining maximum feasible CAFE standards. When NHTSA has introduced additional compliance mechanisms such as AC efficiency and ''off-cycle'' technology fuel improvement values, NHTSA has considered those technologies as available in the analysis. Thus, the analysis for this final rule includes assumptions about manufacturers' use of those technologies, as detailed in Chapter 2 of the accompanying TSD.

In developing the proposal, NHTSA explained that it was aware that some stakeholders had previously requested that we interpret 32902(h) to erase completely all knowledge of BEVs' existence from the analysis, not only restricting their application during the standard-setting years, but restricting their application entirely, for any reason, and deleting them from the existing fleet that NHTSA uses to create an analytical reference baseline. PHEVs would correspondingly be counted simply as strong hybrids, considered only in ''charge-sustaining'' mode. In the NPRM, NHTSA continued to restrict the application of BEVs (and other dedicated alternative fueled vehicles) during standard-setting years (except as is necessary to model compliance with state ZEV programs), and to count PHEVs only in charge-sustaining mode during that time frame, which for this final rule is model years 2027–2032. NHTSA's proposal analysis also mandated the same compliance solution (based on compliance with the reference baseline standards) for all regulatory alternatives for the model years 2022–2026 period. This was intended to ensure that the model does not simulate manufacturers creating new BEVs prior to the standard-setting years in anticipation of the need to comply with the CAFE standards during those standard-setting years. Additionally, because the model is restricted (for purposes of the standard-setting analysis) from applying BEVs during model years 2027–2032 (again, except as is necessary to model compliance with state ZEV programs), it literally cannot apply BEVs in those model years in an effort to reach compliance in subsequent model years. NHTSA did not take the additional step of removing BEVs from the reference baseline fleet, and continued to assume that manufacturers would meet their California ZEV obligations and deployment commitments whether or not NHTSA sets new CAFE standards. Those manufacturer efforts were reflected in the reference baseline fleet. Thus, in the NPRM, NHTSA interpreted the 32902(h) prohibition as preventing NHTSA from setting CAFE standards that effectively require *additional* application of dedicated alternative fueled vehicles in response to those standards, not as preventing NHTSA from being aware of the existence of dedicated alternative fueled vehicles that are already being produced for other reasons besides CAFE standards. Modeling the application of BEV technology in model years outside the standard-setting years allowed NHTSA to account for BEVs that manufacturers may produce for reasons other than the CAFE standards, without accounting for those BEVs that would be produced *because of* the CAFE standards. This is consistent with Congress' intent, made evident in the statute, that NHTSA does not consider the potential for manufacturers to comply with CAFE standards by producing additional dedicated alternative fuel automobiles. We further explained that OMB Circular A–4 directs agencies to conduct cost-benefit analyses against a reference baseline that represents the world in the absence of further regulatory action, and that an

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[1233] *See* OMB, FPISC, and CEQ, 2023, Memorandum M–23–14: Implementation Guidance for the Biden-Harris Permitting Action Plan. Available at: *https://www.whitehouse.gov/wp-content/uploads/2023/03/M-23-14-Permitting-Action-Plan-Implementation-Guidance_OMB_FPISC_CEQ.pdf* (last accessed Mar. 28, 2024).

[1234] 49 U.S.C. 32902(h).

artificial reference baseline that pretends that dedicated alternative fueled vehicles do not exist would not be consistent with that directive. We concluded that we could not fulfill our statutory mandate to set maximum feasible CAFE standards without understanding these real-world reference baseline effects.

In the NPRM, NHTSA also tested the possible effects of this interpretation on NHTSA's analysis by conducting several sensitivity cases: one which applied the EPCA standard setting year restrictions from model years 2027–2035, one which applied the EPCA standard setting year restrictions from model years 2027–2050, and one which applied the EPCA standard setting year restrictions for all model years covered by the analysis. NHTSA concluded that none of the results of these sensitivity analyses were significant enough to change our position on what regulatory alternative was maximum feasible.

Before discussing the comments, we note, as we did in the NPRM, that NHTSA is aware of challenges to its approach in *Natural Resources Defense Council* v. *NHTSA,* No. 22–1080 (D.C. Cir.), but as of this final rule, no decision has yet been issued in this case.

NHTSA received comments from numerous stakeholders on this issue.

A number of commenters opposed the agency's approach in the proposal. These commenters included:

- Representatives of the auto industry, including the Alliance,[1235] as well as several individual manufacturers: BMW,[1236] Toyota,[1237] Volkswagen,[1238] Kia,[1239] and Stellantis;[1240]
- NADA;[1241]
- The Motorcycle Riders Foundation;[1242]
- Representatives of the oil industry, including Valero,[1243] API,[1244] and the AFPM;[1245]
- Entities involved in the renewable fuels and ethanol industry, including a joint comment from RFA, NCGA, NFU, NACS, NATSO, and SIGMA (RFA *et al.* 1), [1246] a separate, more detailed joint comment from RFA, NCGA, and NFU (RFA *et al.* 2).[1247] ACE),[1248] KCGA,[1249] SIRE,[1250] NCB,[1251] CAE,[1252] MME,[1253] WPE,[1254] Growth Energy,[1255] and HCP;[1256]
- Various other energy industry commenters, including Absolute Energy[1257] and the Institute for Energy Research;[1258]
- The National Association of Manufacturers;[1259]
- A joint comment led by NACS;[1260] and
- Non-governmental organizations, including the America First Policy Institute,[1261] CEI,[1262] and the Heritage Foundation.[1263]

NHTSA also received comments that were generally supportive of its proposed approach from MEMA,[1264] Lucid,[1265] a joint comment from several NGOs,[1266] and IPI.[1267]

NHTSA also received two comments from different coalitions of States, one led by West Virginia that opposed the agency's approach,[1268] while the other, led by California and also supported by several local governments, supported the agency's approach.[1269]

Generally, the views expressed by commenters were consistent with views and arguments made in the prior CAFE rule and during the ongoing litigation. Further, commenters who opposed our approach to implementing this provision opposed it in its entirety. That is, commenters either uniformly opposed any consideration of electrification (*e.g.,* whether that be due to market-driven factors or state programs, or whether in the reference baseline or beyond the standard-setting years), or, made most clearly in the case of the States and Cities comment, supported all aspects of our proposed approach. Similarly, commenters who opposed the agency's approach to considering BEVs under 32902(h)(1) also opposed how the agency had considered PHEVs under (h)(2) and credits under (h)(3). This is not surprising, as all of these particular questions stem from the more general question of how NHTSA may ''consider'' these vehicles and flexibilities. Thus, in the below discussion, we typically discuss the comments and our response broadly as applying to all uses of BEVs in either the reference baseline or outside the standard-setting years.

The agency continues to find arguments that it should not consider real-world increases in BEVs and PHEVs that occur due to factors other than the CAFE requirements, both in constructing the reference baseline and outside the standard-setting years, to be unpersuasive. As discussed in the proposal and in the prior rulemaking, to do so would unnecessarily divorce the CAFE standards from how the world would most likely exist in the absence of our program.

Commenters opposing the agency's inclusion of BEVs as part of the reference baseline fleet relied on three primary categories of argument—two of which are purely legal, while the third

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[1235] The Alliance, Docket No. NHTSA–2023–0022–60652, Attachment 2, at 6; Attachment 3, at 2–7.

[1236] BMW, Docket No. NHTSA–2023–0022–58614, at 1.

[1237] Toyota, Docket No. NHTSA–2023–0022–61131, at 11.

[1238] Volkswagen, Docket No. NHTSA–2023–0022–58702, at 3.

[1239] Kia, Docket No. NHTSA–2023–0022–58542, at 4.

[1240] Stellantis, Docket No. NHTSA–2023–0022–61107, at 9.

[1241] NADA, Docket No. NHTSA–2023–0022–58200, at 9.

[1242] Motorcycle Riders Foundation, Docket No. NHTSA–2023–0022–63054, at 1–2.

[1243] Valero, Docket No. NHTSA–2023–0022–58547, at 4, 11.

[1244] API, Docket No. NHTSA–2023–0022–60234, at 5–8.

[1245] AFPM, Docket No. NHTSA–2023–0022–61911, at 27–30.

[1246] RFA *et al.* 1, Docket No. NHTSA–2023–0022–57720, at 2.

[1247] RFA *et al* 2, Docket No. NHTSA–2023–0022–41652, at 11–14.

[1248] ACE, Docket No. NHTSA–2023–0022–60683, at 2.

[1249] KCGA, Docket No. NHTSA–2023–0022–59007, at 2.

[1250] SIRE, Docket No. NHTSA–2023–0022–57940, at 2.

[1251] NCB, Docket No. NHTSA–2023–0022–53876, at 2.

[1252] CAE, Docket No. NHTSA–2023–0022–61599, at 2.

[1253] MME, Docket No. NHTSA–2023–0022–50861, at 1.

[1254] WPE, Docket No. NHTSA–2023–0022–52616, at 2.

[1255] Growth Energy, Docket No. NHTSA–2023–0022–61555, at 1.

[1256] HCP, Docket No. NHTSA–2023–0022–59280, at 1.

[1257] Absolute Energy, Docket No. NHTSA–2023–0022–50902, at 2.

[1258] IER, Docket No. NHTSA–2023–0022–63063, at 1–2.

[1259] NAM, Docket No. NHTSA–2023–0022–59203, at 2–3 (NHTSA–2023–0022–59289 is a duplicate comment).

[1260] NACS, Docket No. NHTSA–2023–0022–61070, at 11.

[1261] America First Policy Institute, Docket No. NHTSA–2023–0022–61447, at 6.

[1262] CEI, Docket No. NHTSA–2023–0022–61121, at 2, 7.

[1263] Heritage Foundation, Docket No. NHTSA–2023–0022–61952, at 4.

[1264] MEMA, Docket No. NHTSA–2023–0022–59204, at 9–10.

[1265] Lucid, Docket No. NHTSA–2023–0022–50594.

[1266] Joint NGOs, Docket No. NHTSA–2023–0022–61944, Appendix 2, at 56.

[1267] IPI, Docket No. NHTSA–2023–0022–60485, at 29–31.

[1268] West Virginia Attorney General's Office, Docket No. NHTSA–2023–0022–63056, at 1–8.

[1269] States and Cities, Docket No. NHTSA–2023–0022–61904, Attachment 2, at 39–40.

concerns the effect of NHTSA's approach on whether the proposed standards are achievable.[1270]

First, commenters opposing NHTSA's proposed approach argued that the language of EPCA prohibited NHTSA's approach to the inclusion of BEVs in the reference baseline. The level of detail provided in their comment on this issue varied across commenters, with the coalition of State commenters led by West Virginia providing the most extensive arguments.[1271] Regardless of detail, all comments revolved around the central question of what it means for NHTSA to "consider" electrification in this context. West Virginia and commenters expressing similar views argue that the prohibition here is broad and thus the presence of BEVs should, as the Alliance put it, be excluded "for any purpose whatsoever," [1272] or as West Virginia put it, "not in the reference baseline, not in technology options, and not in compliance paths." [1273] According to many of these commenters, NHTSA's interpretation conflicts with the "plain meaning" of the text and instead relies on, as RFA *et al.* 2 argued, NHTSA to "add words to the Act" that are not present.[1274] West Virginia also argued that the proposed approach would frustrate both the intent of EPCA to provide incentives for dual-fueled vehicles rather than mandate them, and the Renewable Fuel Standards program, which exists to incentivize biofuels.[1275] Other commenters expressed similar concerns that NHTSA's approach prioritized EVs at the expense of other vehicle technologies or compliance paths.[1276]

NHTSA remains unpersuaded by these arguments. The statute makes clear that NHTSA "may not consider the fuel economy" of BEVs (among others) when "carrying out subsections (c), (f), and (g) of this section." Which is to say, for purposes of this rulemaking, the prohibition applies only when NHTSA is making decisions about whether the CAFE standards are maximum feasible under 32902(c). NHTSA is not reading any additional words into the statutory text, but instead is reading the entire relevant provision, rather than a single word in isolation without the necessary context. In making the maximum feasible determination in this rule, as in all previous rules, NHTSA is clear that it does not consider that BEVs could be used to meet new CAFE standards. Instead, NHTSA models a cost-effective pathway to compliance with potential new CAFE standards that includes no new BEVs in response to the standards, and that counts PHEVs in charge-sustaining mode only, avoiding consideration of their electric-only-operation fuel economy. Consequently, NHTSA is in no way pushing manufacturers toward electrification—just the opposite, as without this provision, NHTSA would almost certainly include pathways involving increased electrification, which would provide the agency with more flexibility in determining what standards could be maximum feasible. Without the restriction on considering electrification, these standards would be significantly more stringent and achieve significantly greater fuel economy benefits. Commenters asserting favorable treatment of BEVs appear to be arguing with other policies of Federal and State governments, such as the IRA credits and the California ZEV program, and with manufacturer plans to deploy electric vehicles independent of any legal requirements. These are other policies and business plans that exist separate from CAFE. NHTSA chooses to acknowledge that these policies and commitments (and other factors) exist when developing the regulatory reference baseline and considering years after the standard-setting time frame, rather than ignoring them, but when it comes to determining maximum feasible standards NHTSA does not consider these technologies.

Commenters opposing NHTSA's interpretation argue that the prohibition should be expanded beyond this determination. They assert that Congress intended NHTSA to ignore BEVs entirely, even when, as is the case here, there is clear evidence that significant BEVs are *already* in the fleet and their numbers are anticipated to grow significantly during the rulemaking time frame independent of the CAFE standards. As NHTSA explained in the NPRM, doing so would require NHTSA to ignore what is occurring with the fleet separate from the CAFE program. NHTSA would thus be attempting to determine maximum feasible CAFE standards on the foundation of a fleet that it knows is divorced from reality. The agency does not believe that this was Congress' intent or that it is a proper construction of the statute. Instead, as the statute clearly states, Congress only required that NHTSA could not issue standards that are presumed on the use of additional BEVs and other alternative fueled vehicles.

Nowhere does EPCA/EISA say that NHTSA should not consider the best available evidence in establishing the regulatory reference baseline for its CAFE rulemakings. As explained in Circular A–4, "The benefits and costs of a regulation are generally measured against a no-action baseline: an analytically reasonable forecast of the way the world would look absent the regulatory action being assessed, including any expected changes to current conditions over time." [1277] The Alliance commented that "an OMB Circular does not trump a clear statutory requirement." [1278] This is, of course, correct and NHTSA does not intend to imply anything else. Instead, NHTSA makes clear that its interpretation of this provision restricts the agency's analytical options when analyzing what standards are maximum feasible, while being consistent with A–4's guidance about how best to construct the reference baseline. Thus, absent a clear indication to blind itself to important facts, NHTSA continues to believe that the best way to implement its duty to establish maximum feasible CAFE standards is to establish as realistic a reference baseline as possible, including, among other factors, the most likely composition of the fleet.

Second, several commenters argued that including BEVs in the reference baseline would run afoul of the "major questions doctrine." West Virginia made this argument most comprehensively, stating that "this proposal is about transforming the American auto markets to lead with EVs. It aims to morph a longstanding scheme to regulate internal combustion engine vehicles into one that erases them from the market." [1279] These arguments misunderstand the major questions doctrine. NHTSA has clear authority to establish CAFE

[1270] Technical comments concerning the construction of the baseline are discussed in Section IV above; this discussion is limited to the legal questions concerning the application of this section.

[1271] West Virginia Attorney General's office, Docket No. NHTSA–2023–0022–60356, at 1–8.

[1272] The Alliance, Docket No. NHTSA–2023–0022–60652, Attachment 3, at 2.

[1273] West Virginia Attorney General's office, Docket No. NHTSA–2023–0022–60356, at 6.

[1274] RFA *et al.* 2, Docket No. Docket No. NHTSA–2023–0022–41652, at 11–12.

[1275] West Virginia Attorney General's office, Docket No. NHTSA–2023–0022–60356, at 6–7.

[1276] *See, e.g.,* CAE, Docket No. NHTSA–2023–0022–61599, at 2; MME, Docket No. NHTSA–2023–0022–50861, at 1; WPE, Docket No. NHTSA–2023–0022–52616, at 2.

[1277] OMB Circular A–4, "Regulatory Analysis" Nov. 9, 2003, at 11. Note that Circular A–4 was recently updated; the initial version was in effect at the time of the proposal.

[1278] The Alliance, Docket No. NHTSA–2023–0022–60652, Attachment 3, at 2.

[1279] West Virginia Attorney General's office, Docket No. NHTSA–2023–0022–63056, at 6–8; *see also* Valero, Docket No. NHTSA–2023–0022–58547, at 4. Several other commenters (*e.g.,* NACS and CEI) argued that the rule more broadly raised major questions; those comments are addressed in Section VI.B.

standards, and thus simply establishing new ones that are more stringent than prior ones cannot be considered to be a ''major question.'' Moreover, commenters imply a motive to this rulemaking that appears nowhere in the rule, which is simply about establishing CAFE standards that include marginal increases to the prior standards. And finally, 32902(h) is the literal provision that prohibits any attempt by NHTSA to actually require electrification. The very provision that these commenters believe somehow raises major questions is the provision that prevents NHTSA from actually taking that action.

Third, several other commenters, including the Alliance,[1280] Stellantis,[1281] NACS,[1282] and AFPM,[1283] argued that the proposed standards were technologically achievable only if BEVs were considered in the reference baseline and, based on their view that NHTSA is prohibited from taking this action in the reference baseline, the standards were not in fact maximum feasible. Other commenters were not so explicit in making this argument, but their general theme, that NHTSA's approach to the reference baseline led to standards that were beyond maximum feasible, is consistent with many otherwise purely legalistic objections. Finally, the environmental NGOs recommended that the agency conduct sensitivity analyses examining this issue.[1284]

At the outset, NHTSA stresses that it disagrees with the basic premise here, and as discussed above, the agency believes that it is permitted to include electrification in the reference baseline and in the years following the rulemaking time frame. Leaving that aside, it is also important to note that, in response to comments from the auto industry and others, the final CAFE standards for light trucks have changed significantly since the proposal. Thus, any concerns about the practicability of achieving the proposed standards are clearly reduced in this final rule.

That said, NHTSA also modeled a No ZEV alternative baseline. The No ZEV case removed not only the electric vehicles that would be deployed to comply with ACC I, but also those that would be deployed consistent with manufacturer commitments to deploy additional electric vehicles regardless of legal requirements, consistent with the levels under ACC II. NHTSA also modeled three cases that extend the EPCA standard setting year constraints (no application of BEVs and no credit use) beyond years considered in the reference baseline.

When the standards are assessed relative to the no ZEV alternative baseline, the industry as a whole overcomplies with the final standards in every year covered by the standards. The passenger car fleet overcomplies handily, and the light truck fleet overcomplies in model years 2027–2030, until model year 2031 when the fleet exactly meets the standard. Individual manufacturers' compliance results are also much less dramatically affected than comments would lead one to believe; while some manufacturers comply with the 4 percent per year light truck stringency increases from the proposal without ZEV in the reference baseline, a majority of manufacturers comply in most or all years under the final light truck standards. In general, the manufacturers that have to work harder to comply with CAFE standards without ZEV in the reference baseline are the same manufacturers that have to work harder to comply with CAFE standards with no ZEV in the reference baseline. For example, General Motors sees higher technology costs and civil penalties to comply with the CAFE standards over the five years covered by the standards; however, this is expected as they are starting from a lower reference baseline compliance position. General Motors seems to be the only outlier, and for the rest of the industry technology costs are low and civil penalty payments are nonexistent in many cases.

Net benefits of CAFE standards increase in the no ZEV case, which is expected as benefits related to increased fuel economy attributable to state ZEV programs and automaker-driven deployment of electric vehicles in the reference baseline are now attributable to the CAFE program. This includes additional decreases in fuel use, CO_2 emissions, and criteria emissions deaths from the application of fuel economy-improving technology in response to CAFE standards. In addition, consumer fuel savings attributable to state ZEV programs and non-regulatory manufacturer ZEV deployment in the reference baseline are now attributable to the CAFE program: in 2031, the final standards show fuel savings of over $1,000 for consumers buying model year 2031 vehicles.

Similar trends hold true for the EPCA standard setting year constraints cases. Examining the most restrictive scenario, which does not allow BEV adoption in response to CAFE standards in any year when the CAFE Model adds technology to vehicles (2023–2050, as 2022 is the reference baseline fleet year), the industry, as a whole, still overcomplies in every year from model year 2027–2031, in both the passenger car and light truck fleets. Some manufacturers again have to work harder in individual model years or compliance categories, but the majority comply or overcomply in both compliance categories of vehicles. Again, General Motors is the only manufacturer that sees notable increases in their technology costs over the reference baseline, however their civil penalty payments are low, at under $500 million total over the five-year period covered by the new standards. Net benefits attributable to CAFE standards do decrease from the central analysis under the EPCA constraints case—but they remain significantly positive. However, as discussed in more detail below, net benefits are just one of many factors considered when NHTSA sets fuel economy standards.

This alternative baseline and these sensitivity cases offer two conclusions. First, contrary to the Alliance's and other commenter's concerns, the difference between including BEVs in the base case for non-CAFE reasons and excluding them are not great—thus, NHTSA would make the same determination of what standards are maximum feasible under any of the analyzed scenarios.[1285] And second, this lack of dispositive difference in the alternative baseline and sensitivity cases shows that the interpretive concerns raised by commenters, even if correct, would not lead to a different decision by NHTSA on the question of what is maximum feasible. This reaffirms NHTSA's point all along: understanding the reference baseline is a crucial part of determining the costs and benefits of various regulatory alternatives, but the real decision making is informed by the analysis NHTSA conducts when ''carrying out'' its duty to determine the appropriate standards.

The results of the sensitivity cases not discussed here are discussed in detail in Chapter 9 of the FRIA. Chapter 9 also reports other metrics not reported here like categories of technology adoption and physical impacts such as changes in fuel use and greenhouse gas emissions.

On a somewhat similar point, America First Policy Institute argued that language from NHTSA acknowledging that real-world compliance may differ from modeled

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[1280] Alliance, Docket No. NHTSA–2023–0022–60652, Attachment 3, at 5–9.

[1281] Stellantis, Docket No. NHTSA–2023–0022–61107, at 9.

[1282] NACS, Docket No. NHTSA–2023–0022–61070, at 11.

[1283] AFPM, Docket No. NHTSA–2023–0022–61911, at 30.

[1284] Joint NGO comments, Docket No. NHTSA–2023–0022–61944, Appendix 2, at 56.

[1285] See RIA Chapter 9 for sensitivity run results.

compliance in the standard-setting runs indicated that the standards would be met by additional electrification.[1286] This concern misunderstands NHTSA's point. As always, NHTSA's modeling is intended to show one potential path toward compliance that is based on the statutory constraints and NHTSA's assumptions about costs, effectiveness, and other manufacturer and consumer behaviors. Actual compliance will always be different, both due to the fact that compliance options do not include the statutory limitations discussed here, and also simply because NHTSA cannot perfectly predict the future. NHTSA's point is just to acknowledge this reality, not to make any implications about how it believes compliance should occur. West Virginia made a similar point, arguing that ''everything in the CAFE model assumes the fastest possible adoption of electrification.'' [1287] This, too, misunderstands NHTSA's modeling, which applies a technologically-neutral approach consistent with the statutory limitations in the standard-setting years.

(6) Other Considerations in Determining Maximum Feasible CAFE Standards

NHTSA has historically considered the potential for adverse safety effects in setting CAFE standards. This practice has been upheld in case law.[1288] Heritage Foundation commented that ''the proposed rule will cause an increase in traffic deaths and serious injuries on America's highways,'' both because automakers will make vehicles smaller and lighter in response to the standards, and because consumers will retain older vehicles for longer rather than buying newer, more expensive vehicles.[1289] Heritage Foundation further argued that NHTSA inappropriately ''downplayed and minimized the loss of lives and serious injuries its standards will cause by attributing many of these . . . to EPA's parallel rules and to the EV mandates issued by CARB—in other words, by assuming them away and not counting them for purposes of the current rulemaking.'' [1290] For this final rule, as explained in Chapter 8.2.4.6 of the accompanying FRIA, across nearly all alternatives (with the exception of PC6LT8), mass changes relative to the reference baseline result in small reductions in overall fatalities, injuries, and property damage, due to changes in the model's fleet share accounting such that the relatively beneficial effect of mass reduction on light trucks results in safety benefits. Rebound and scrappage effects increase fatalities as policy alternatives become more stringent, but these effects are relatively minor and NHTSA discusses its consideration of these effects in Section VI.D below. These safety outcomes for mass reduction, rebound, and scrappage are also present in the No ZEV alternative baseline analysis. With regard to NHTSA's analytical decision not to include safety effects associated with activities occurring in the reference baseline, this is because NHTSA does not include reference baseline effects in its incremental analysis of the effects of regulatory alternatives, because to do so would obscure the effects of *NHTSA's action,* which is what NHTSA is supposed to consider. If NHTSA were to include baseline safety effects, NHTSA should then also include baseline CO_2 reductions, which would be demonstrably absurd because NHTSA's actions did not cause those—they belong to the reference baseline because their cause is something other than CAFE standards. NHTSA disagrees that it would be appropriate for NHTSA's rule to account for reference baseline safety effects.

b. Heavy-Duty Pickups and Vans

Statutory authority for the fuel consumption standards established in this document for HDPUVs is found in Section 103 of EISA, codified at 49 U.S.C. 32902(k). That section authorizes a fuel efficiency improvement program, designed to achieve the maximum feasible improvement, to be created for (among other things) HDPUVs. Congress directed that the standards, test methods, measurement metrics, and compliance and enforcement protocols for HDPUVs be ''appropriate, cost-effective, and technologically feasible,'' while achieving the ''maximum feasible improvement'' in fuel efficiency. These three factors are similar to and yet somewhat different from the four factors that NHTSA considers for passenger car and light truck standards, but they still modify ''feasible'' in ''maximum feasible'' in the context of the HDPUV final rule beyond a plain meaning of ''capable of being done.''[1291] Importantly, NHTSA interprets them as giving NHTSA similarly broad authority to weigh potentially conflicting priorities to determine maximum feasible standards.[1292] Thus, as with passenger car and light truck standards, NHTSA believes that it is firmly within our discretion to weigh and balance the HDPUV factors in a way that is technology-forcing, as evidenced by this final rule, but not in a way that requires the application of technology that will not be available in the lead time provided by this final rule, or that is not cost-effective.

While NHTSA has sought in the past to set HDPUV standards that are maximum feasible by balancing the considerations of whether standards are appropriate, cost-effective, and technologically feasible, NHTSA has not sought to interpret those factors more specifically. In the interest of helping NHTSA ground the elements of its analysis in the words of the statute, without intending to restrict NHTSA's consideration of any important factors, NHTSA is interpreting the 32902(k)(2) factors as follows.

(1) Appropriate

Given that the overarching purpose of EPCA is energy conservation, the amount of energy conserved by standards should inform whether standards are appropriate. When considering energy conservation, NHTSA may consider things like average estimated fuel savings to consumers, average estimated total fuel savings, and benefits to our nation's energy security, among other things. Environmental benefits are another facet of energy conservation, and NHTSA may consider carbon dioxide emissions avoided, criteria pollutant and air toxics emissions avoided, and so forth. Given NHTSA's additional mission as a safety agency, NHTSA may also consider the possible safety effects of different potential standards in determining whether those standards are

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[1286] America First Policy Institute, Docket No. NHTSA–2023–0022–61447, at 6.

[1287] West Virginia Attorney General's office, Docket No. NHTSA–2023–0022–63056, at 4.

[1288] As courts have recognized, ''NHTSA has always examined the safety consequences of the CAFE standards in its overall consideration of relevant factors since its earliest rulemaking under the CAFE program.'' *Competitive Enterprise Institute* v. *NHTSA,* 901 F.2d 107, 120 n. 11 (D.C. Cir. 1990) (''CEI–I'') (citing 42 FR 33534, 33551 (Jun. 30, 1977)). Courts have consistently upheld NHTSA's implementation of EPCA in this manner. *See, e.g., Competitive Enterprise Institute* v. *NHTSA,* 956 F.2d 321, 322 (D.C. Cir. 1992) (''CEI–II'') (in determining the maximum feasible standard, ''NHTSA has always taken passenger safety into account'') (citing CEI–I, 901 F.2d at 120 n. 11); *Competitive Enterprise Institute* v. *NHTSA,* 45 F.3d 481, 482–83 (D.C. Cir. 1995) (''CEI–III'') (same); *Center for Biological Diversity* v. *NHTSA,* 538 F.3d 1172, 1203–04 (9th Cir. 2008) (upholding NHTSA's analysis of vehicle safety issues associated with weight in connection with the model years 2008–2011 CAFE rulemaking).

[1289] Heritage Foundation, Docket No. NHTSA–2023–0022–61952, at 8.

[1290] *Id.*

[1291] *See Center for Biological Diversity* v. *NHTSA,* 538 F. 3d 1172, 1194 (9th Cir. 2008).

[1292] Where Congress has not directly spoken to a potential issue related to such a balancing, NHTSA's interpretation must be a ''reasonable accommodation of conflicting policies . . . committed to the agency's care by the statute.'' *Id.* at 1195.

appropriate. Effects on the industry that do not relate directly to ''cost-effectiveness'' may be encompassed here, such as estimated effects on sales and employment, and effects *in* the industry that appear to be happening for reasons other than NHTSA's regulations may also be encompassed. NHTSA interprets ''appropriate'' broadly, as not prohibiting consideration of any relevant elements that are not already considered under one of the other factors.

AFPM commented that ''appropriate'' should also encompass ''the significant costs to commercial fleet operators associated with purchasing, using and maintaining HDPUV ZEVs,'' suggesting that maintenance costs would be higher, and that refueling HDPUV ZEVs would ''require significant time to accommodate charging needs, which results in costly vehicle down-time and increased labor expenses.'' [1293] NHTSA disagrees that this is likely for HDPUV BEVs. While HD BEVs could require longer recharging times due to the need for much larger battery packs to accommodate heavy-duty use cycles, HDPUV BEVs are much closer to their light truck BEV counterparts given the sizes of their battery packs, and therefore NHTSA would expect similar charging needs for HDPUVs. Sections II.B and III.D of this preamble discuss these issues in more detail.

AFPM also commented that ''appropriate'' should encompass energy security considerations related specifically to electric vehicles.[1294] As discussed in the proposal, NHTSA agrees that energy security considerations may be part of whether HDPUV standards are ''appropriate,'' and NHTSA also agrees with AFPM that energy security considerations related to electric vehicles are relevant to this inquiry, given that NHTSA is allowed to consider electrification fully in determining maximum feasible HDPUV standards.

However, NHTSA disagrees with AFPM that energy security issues specific to BEVs should necessarily change our decision for this final rule. As discussed above in Section VI.A.5.a.(4)(d) for passenger cars and light trucks, the energy security considerations associated with the supply chains for internal combustion engine vehicles and for BEVs are being actively addressed through a variety of public and private measures. AFPM's comments identified potential problems but did not acknowledge the many efforts currently underway to address them. Based on all of the above, NHTSA finds that the energy security benefits of more stringent HDPUV standards outweigh any potential energy security drawbacks that are being actively addressed by numerous government and private sector efforts.

(2) Cost-Effective

Congress' use of the term ''cost-effective'' in 32902(k) appears to have a more specific aim than the broader term ''economic practicability'' in 32902(f). In past rulemakings covering HDPUVs, NHTSA has considered the ratio of estimated technology (or regulatory) costs to the estimated value of GHG emissions avoided, and also to estimated fuel savings. In setting passenger car and light truck standards, NHTSA often looks at consumer costs and benefits, like the estimated additional upfront cost of the vehicle (as above, assuming that the cost of additional technology required to meet standards gets passed forward to consumers) and the estimated fuel savings. Another way to consider cost-effectiveness could be total industry-wide estimated compliance costs compared to estimated societal benefits. Other similar comparisons of costs and benefits may also be relevant. NHTSA interprets ''cost-effective'' as encompassing these kinds of comparisons.

NHTSA received no specific comments regarding this interpretation of ''cost-effective,'' and thus finalizes the interpretation as proposed.

(3) Technologically Feasible

Technological feasibility in the HDPUV context is similar to how NHTSA interprets it in the passenger car and light truck context. NHTSA has previously interpreted ''technological feasibility'' to mean ''whether a particular method of improving fuel economy can be available for commercial application in the model year for which a standard is being established,'' as discussed above. NHTSA has further clarified that the consideration of technological feasibility ''does not mean that the technology must be available or in use when a standard is proposed or issued.'' [1295] Consistent with these previous interpretations, NHTSA believes that a technology does not necessarily need to be currently available or already in use for all regulated parties to be ''technologically feasible'' for these standards, as long as it is reasonable to expect, based on the evidence before us, that the technology will be available in the model year in which the relevant standard takes effect.

ACEEE commented that while NHTSA did account for many hybrid and electric HDPUV technologies, NHTSA did not ''take full advantage of the full range of available fuel saving technologies in setting the standards for HDPUVs.'' [1296] NHTSA interprets this comment as suggesting that ACEEE would have preferred to see higher penetration rates for SHEVs and PHEVs (and BEVs) in the analysis in response to NHTSA's proposed and final standards. This is less a question of technological feasibility—of course NHTSA agrees that SHEVs and PHEVs will be available for deployment in the rulemaking time frame—and more a question of cost-effectiveness. NHTSA's analysis for both the proposal and the final rule illustrates that BEVs are cost-effective for certain portions of the HDPUV fleet. If it is cost-effective for vehicles to turn from ICE to BEV, there is no need for them to turn SHEV or PHEV instead. PHEVs do, however, play an important role for heavy-duty pickup trucks, which tend on average to have use cases currently well-suited to a dual-fuel technology. Moreover, if fleetwide standards can be met cost-effectively with certain penetrations of BEVs and PHEVs, setting more stringent standards that could necessitate additional (and perhaps not cost-effective) penetration of SHEVs or advanced ICEV technologies could be technologically feasible, but could well be beyond maximum feasible.

MCGA commented that NHTSA should conduct additional analysis of whether the volumes of BEVs it projected for HDPUVs were technologically feasible, and specifically asked whether critical minerals supplies and charging infrastructure were adequate to render the standards technologically feasible.[1297] Critical minerals supplies and charging infrastructure considerations could potentially bear on whether technology may be deployable in the rulemaking time frame. As with the discussion above regarding energy security, on critical minerals, the available evidence gives NHTSA confidence that supplies will be even more broadly available from stable locations within the rulemaking time frame. Regarding infrastructure, as above, NHTSA

[1293] AFPM, Docket No. -2023–0022–61911, at 86.

[1294] AFPM, Docket No. NHTSA–2023–0022–61911, at 21.

[1295] *Center for Auto Safety* v. *NHTSA,* 793 F.2d 1322, 1325 n. 12 (D.C. Cir. 1986), quoting 42 FR 63, 184 (1977).

[1296] ACEEE, Docket No. NHTSA–2023–0022–60684, at 7.

[1297] MCGA, Docket No. NHTSA–2023–0022–60208, at 16–17.

believes that the use case for HDPUVs is similar enough to light trucks that charging needs for HDPUV BEVs should be similar to charging needs for light truck BEVs, and that extensive public and private efforts to build out that infrastructure are ongoing. Moreover, the HDPUV standards do not begin until model year 2030, by which time NHTSA would expect infrastructure to be even more developed than model year 2027.

NHTSA has concluded that a 10 percent increase in model years 2030–2032 and an 8 percent increase in model years 2033–2035 for the HDPUV fleet (HDPUV108) is maximum feasible. To determine what levels of fuel efficiency standards for HDPUVs would be maximum feasible, EISA requires NHTSA to consider three factors—whether a given fuel efficiency standard would be appropriate, cost-effective, and technologically feasible. Because EISA directs NHTSA to establish the maximum feasible standard, the most stringent alternative that satisfies these three factors is the standard that should be finalized.

In evaluating whether HDPUV standards are technologically feasible, NHTSA considers whether the standards could be met using technology expected to be available in the rulemaking time frame. For HDPUVs, NHTSA takes into account the full fuel efficiency of BEVs and PHEVs, and considers the availability and use of overcompliance credits in this final rule. Given the ongoing transition to electrification, most technology applications between now and model year 2035 would be occurring as a result of reference baseline efforts and would not be an effect of new NHTSA standards. Under the reference baseline, as early as model year 2033, nearly 80 percent of the fleet would be electrified, including SHEV, PHEV, and BEV.

However, both HDPUV10 and HDPUV108 will encourage technology application for some manufacturers while functioning as a backstop for the others, and it remains net beneficial for consumers. When considering harmonization between the HDPUV GHG rules recently finalized by EPA and these fuel efficiency standards, HDPUV108 will best harmonize with EPA's recently finalized standards, realigning with EPA's model year 2032 standards by model year 2034. Moreover, HDPUV108 produces the highest benefit-cost rations for aggregate societal effects as well as when narrowing the focus to private benefits and costs.

B. Comments Regarding the Administrative Procedure Act (APA) and Related Legal Concerns

The APA governs agency rulemaking generally and provides the standard of judicial review for agency actions. To be upheld under the ''arbitrary and capricious'' standard of judicial review under the APA, an agency rule must be rational, based on consideration of the relevant factors, and within the scope of authority delegated to the agency by statute. The agency must examine the relevant data and articulate a satisfactory explanation for its action, including a ''rational connection between the facts found and the choice made.'' [1298] The APA also requires that agencies provide notice and comment to the public when proposing regulations,[1299] as NHTSA did during the NPRM and comment period that preceded this final rule and its accompanying materials.

In a sense, all comments to this (or any) proposed rule raise issues that concern compliance with the APA's requirements. Comments challenging our technical or economic findings imply that the rule was ''arbitrary, capricious, an abuse of discretion, or otherwise not in accordance with law,'' and comments challenging our interpretations imply that the rule is ''in excess of statutory jurisdiction, authority or limitations, or short of statutory right.'' [1300] However, nearly all of those comments are about, or build off of, various substantive issues that commenters have with the rule (*e.g.,* whether the standards are ''maximum feasible'' or whether our technology assumptions are reasonable). Those comments are considered and responded to in the relevant parts of the final rule and accompanying documents. A small number of comments, however, raised issues that were unique to APA compliance. Two commenters, a group led by the Clean Fuels Development Coalition and a separate group led by the Renewable Fuels Association,[1301] [1302] argued that the agency should change its approach to modeling BEVs in the reference baseline and in the years after the rulemaking time frame and that, if the agency adopted this change, NHTSA would be prohibited from finalizing the rule without further comment due to logical outgrowth concerns. As discussed in Section VI.A.5.a(5), NHTSA continues to believe that its proposed approach on these issues is correct; thus, the procedural questions that might arise if NHTSA adopted a new interpretation are not present. Separately, the Landmark Legal Foundation argued that the agency's use of SC–GHG values produced by the Interagency Working Group (IWG) violated the APA because the ''SC–GHG values never underwent the normal and legal required comment and notice period.'' [1303] NHTSA, however, took comment on the appropriate SC–GHG value in the NPRM, and responds to those comments in this final rule. The SC–GHG value used in this final rule is therefore the product of the notice-and-comment process.

NHTSA also received a few comments that argued that the rule, in general, violated the ''major questions doctrine,'' as it has been developed by the Supreme Court. Several of these comments raised this question specifically in relation to the agency's interpretation of 49 U.S.C. 32902(h); those questions are addressed in Section VI.A.5.a(5) above. Two commenters made more general arguments. CEI argued that the rule is intended to ''backstop the administration's electrification agenda,'' which CEI believes is a ''policy decision of vast economic and political significance for which no clear congressional authorization exist.'' [1304] Similarly, NACS argues that ''[b]y effectively mandating the production of EVs, the Proposal violates this judicial doctrine.'' [1305] As NHTSA has explained throughout this final rule, the agency is not mandating electrification, and in fact due to the limitations in 32902(h), *cannot* take such an action. The rule simply sets slightly increased CAFE standards that are based on the agency's long-established and clear authority to set these standards and administer this program. Regardless of how much certain commenters may disagree with the agency's interpretations and conclusions, the agency has ''clear congressional authorization'' to set CAFE standards.

Finally, the agency received a small number of comments that raised constitutional concerns. First, Valero commented that the proposed rule violated numerous constitutional provisions. Valero argued that the rule

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[1298] *Burlington Truck Lines, Inc.* v. *United States,* 371 U.S. 156, 168 (1962).

[1299] 5 U.S.C. 553.

[1300] 5 U.S.C. 706(a), (c).

[1301] CFDC et al., Docket No. NHTSA–2023–0022–62242, at 9.

[1302] RFA et al., Docket No. NHTSA–2023–0022–57625, at 13–14.

[1303] Landmark, Docket No. NHTSA–2023–0022–48725, at 3.

[1304] CEI, Docket No. NHTSA–2023–0022–61121, at 1.

[1305] NACS, Docket No. NHTSA–2023–0022–61070, at 11–12.

violated ''the Takings Clause of the Fifth Amendment, which precludes the taking of private property (or the elimination of entire industries) for public use without just compensation, as contemplated by the Proposal with regard to traditional and renewable liquid fuels and related industries (*e.g.,* asphalt, sulfur, etc.).'' [1306] NHTSA disagrees that this rule could constitute a ''taking'' in this regard, as it simply sets CAFE standards at a marginally higher level than those finalized for model year 2026, nor does it eliminate the ''entire'' ''renewable liquid fuels and related industries,'' given that ICE vehicles remain a valid compliance option available to manufacturers. Valero also commented that ''to the extent the final rule relies on and/or incorporates state ZEV mandates,'' NHTSA violates the Dormant Commerce Clause; the equal sovereignty clause; the Import-Export Clause; the Privileges and Immunities Clause; and the Full Faith and Credit Clause.[1307] To the extent that these claims raise cognizable constitutional concerns, they are with the existence of the ZEV program, which NHTSA neither administers nor approves, and thus are outside the scope of this rulemaking and NHTSA's authority. Landmark Legal Foundation, similar to its comment on APA concerns discussed above, argued that the proposed rule was unconstitutional because it ''relies heavily on SC–GHG valuations which have been created by the IWG[, which was] created unconstitutionally by executive order.''[1308] The SC–GHG developed by the IWG and used in the proposal was simply a value used by the agency that was subject to notice-and-comment, and NHTSA is using a different value developed by EPA for this final rule, as discussed in Chapter 6.2.1 of the accompanying TSD. Moreover, as discussed below, NHTSA recognizes that PC2LT002 does not comprehensively maximize net benefits and concludes that it is nevertheless maximum feasible for economic practicability reasons. Further, the Federal government routinely establishes interagency groups for a wide variety of issues to ensure appropriate coordination across the Federal government; [1309] thus, there is nothing unique about an IWG being established related to climate change, which affects the equities of many Federal agencies. Finally, Our Children's Trust requested that, based on their view of the Public Trust Doctrine, ''NHTSA incorporate[ ] the protection of children's fundamental rights to a safe climate system, defined by the best available science, into future rulemaking, policies, and initiatives,'' [1310] and that, generally, standards be set at a more stringent level.[1311] NHTSA has addressed Our Children's Trust's substantive comments elsewhere in this final rule with regard to their broader constitutional concerns. NHTSA notes that, though it must act consistent with the Constitution, the extent of the agency's authority is limited to what is provided by Congress in statute.

C. National Environmental Policy Act

The National Environmental Policy Act (NEPA) directs that environmental considerations be integrated into Federal decision making process, considering the purpose and need for agencies' actions.[1312] As discussed above, EPCA requires NHTSA to determine the level at which to set CAFE standards for passenger cars and light trucks by considering the four factors of technological feasibility, economic practicability, the effect of other motor vehicle standards of the Government on fuel economy, and the need of the U.S. to conserve energy, and to set fuel efficiency standards for HDPUVs by adopting and implementing appropriate test methods, measurement metrics, fuel economy standards,[1313] and compliance and enforcement protocols that are appropriate, cost-effective, and technologically feasible.[1314] To explore the potential environmental consequences of this rulemaking action, NHTSA prepared a Draft EIS for the NPRM and a and Final EIS for the final rule. The purpose of an EIS is to ''. . .provide full and fair discussion of significant environmental impacts and [to] inform decision makers and the public of reasonable alternatives that would avoid or minimize adverse impacts or enhance the quality of the human environment.'' [1315] This section of the preamble describes results from NHTSA's Final EIS, which is being publicly issued simultaneously with this final rule.

EPCA and EISA require that the Secretary of Transportation determine the maximum feasible levels of CAFE standards in a manner that sets aside the potential use of CAFE credits or application of alternative fuel technologies toward compliance in model years for which NHTSA is issuing new standards. NEPA, however, does not impose such constraints on analysis; instead, its purpose is to ensure that ''Federal agencies consider the environmental impacts of their actions in the decision-making process.'' [1316] As the environmental impacts of this action depend on manufacturers' actual responses to standards, and those responses are not constrained by the adoption of alternative fueled technologies or the use of compliance credits, the Final EIS is based on ''unconstrained'' modeling rather than ''standard setting'' modeling. The ''unconstrained'' analysis considers manufacturers' potential use of CAFE credits and application of alternative fuel technologies in order to disclose and allow consideration of the real-world environmental consequences of the final standards and alternatives.

NHTSA conducts modeling both ways in order to reflect the various statutory requirements of EPCA/EISA and NEPA. The rest of the preamble, and importantly, NHTSA's balancing of relevant EPCA/EISA factors explained in Section VI.D, employs the ''standard setting'' modeling in order to aid the decision-maker in avoiding consideration of the prohibited items in 49 U.S.C. 32902(h) in determining maximum feasible standards, but as a result, the impacts reported here may

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[1306] Valero, Docket No. NHTSA–2023–0022–58547, at 15.

[1307] *Id.*

[1308] Landmark, Docket No. NHTSA–2023–0022–48725, at 3.

[1309] To use but one high-profile example among many, the recent Executive Order on artificial intelligence provides that ''the Director of OMB shall convene and chair an interagency council to coordinate the development and use of AI in agencies' programs and operations, other than the use of AI in national security systems.'' E.O. 14110, ''Safe, Secure, and Trustworthy Development and Use of Artificial Intelligence,'' at Section 10.1 (Oct. 30, 2023).

[1310] OCT, Docket No. NHTSA–2023–0022–51242, at 7.

[1311] *Id.* at 1–2.

[1312] NEPA is codified at 42 U.S.C. 4321–47. The Council on Environmental Quality (CEQ) NEPA implementing regulations are codified at 40 CFR parts 1500 through 1508.

[1313] In the Phase 1 HD Fuel Efficiency Improvement Program rulemaking, NHTSA, aided by the National Academies of Sciences report, assessed potential metrics for evaluating fuel efficiency. NHTSA found that fuel economy would not be an appropriate metric for HD vehicles. Instead, NHTSA chose a metric that considers the amount of fuel consumed when moving a ton of freight (*i.e.,* performing work). As explained in the Phase 2 HD Fuel Efficiency Improvement Program Final Rule, this metric, delegated by Congress to NHTSA to formulate, is not precluded by the text of the statute. The agency concluded that it is a reasonable way by which to measure fuel efficiency for a program designed to reduce fuel consumption. Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles—Phase 2; Final Rule, 81 FR 73478, 73520 (Oct. 25, 2016).

[1314] 49 U.S.C. 32902(k)(2).

[1315] 40 CFR 1502.1.

[1316] 40 CFR 1500.1(a).

differ from those reported elsewhere in the preamble.[1317]

NHTSA's overall EIS-related obligation is to "take a 'hard look' at the environmental consequences" as appropriate.[1318] Significantly, "[i]f the adverse environmental effects of the proposed action are adequately identified and evaluated, the agency is not constrained by NEPA from deciding that other values outweigh the environmental costs." [1319] The agency must identify the "environmentally preferable" alternative but need not adopt it.[1320] "Congress in enacting NEPA . . . did not require agencies to elevate environmental concerns over other appropriate considerations." [1321] Instead, NEPA requires an agency to develop and consider alternatives to the proposed action in preparing an EIS.[1322] The statute and implementing regulations do not command an agency to favor an environmentally preferable course of action, only that it makes its decision to proceed with the action after taking a hard look at the potential environmental consequences and consider the relevant factors in making a decision among alternatives.[1323] As such, NHTSA considered the impacts reported in the Final EIS, in addition to the other information presented in this preamble, the TSD, and the FRIA, as part of its decision-making process.

The agency received several comments on the Draft EIS. Comments regarding the Draft EIS, including the environmental analysis, are addressed in Appendix B of the Final EIS. NHTSA addresses substantive comments that concern the rule but that are not related to the EIS in this preamble and its associated documents in the public docket.

When preparing an EIS, NEPA requires an agency to compare the potential environmental impacts of its proposed action and a reasonable range of alternatives. Because NHTSA is setting standards for passenger cars, light trucks, and HDPUVs,[1324] and because evaluating the environmental impacts of this rulemaking requires consideration of the impacts of the standards for all three vehicle classes, the main analyses of direct and indirect effects of the action alternatives presented in the Final EIS reflect: (1) the environmental impacts associated with the CAFE standards for LDVs, and (2) the environmental impacts associated with the HDPUV FE standards. The analyses of cumulative impacts of the action alternatives presented in this EIS reflect the cumulative or combined impact of the two sets of standards that are being set by NHTSA in this final rule, in addition to the model year 2032 augural year standards being set forth.

In the DEIS, NHTSA analyzed a CAFE No-Action Alternative and four action alternatives for passenger cars and light trucks, along with a HDPUV FE No-Action Alternative and three action alternatives for HDPUV FE standards. In the Final EIS, NHTSA has analyzed a CAFE No-Action Alternative and five action alternatives for passenger car and light truck standards, along with a HDPUV FE No-Action Alternative and four action alternatives for HDPUV FE standards.[1325] The alternatives represent a range of potential actions NHTSA could take, and they are described more fully in Section IV of this preamble, Chapter 1 of the TSD, and Chapter 3 of the FRIA. The estimated environmental impacts of these alternatives, in turn, represent a range of potential environmental impacts that could result from NHTSA's setting maximum feasible fuel economy standards for passenger cars and light trucks and fuel efficiency standards for HDPUVs.

To derive the direct, indirect, and cumulative impacts of the CAFE standard action alternatives and the HDPUV FE standard action alternatives, NHTSA compared each action alternative to the relevant No-Action Alternative, which reflects reference baseline trends that would be expected in the absence of any further regulatory action. More specifically, the CAFE No-Action Alternative in the Draft and Final EIS assumes that the model year 2026 CAFE standards finalized in 2022 continue in perpetuity. [1326] [1327] The HDPUV FE No-Action Alternative in the Draft and Final EIS assumes that the model year 2027 HDPUV FE standards finalized in the Phase 2 program continue in perpetuity.[1328] Like all of the action alternatives, the No-Action Alternatives also include other considerations that will foreseeably occur during the rulemaking time frame, as discussed in more detail in Section IV above. The No-Action Alternatives assume that manufacturers will comply with ZEV programs set by California and other Section 177 states and their deployment commitments consistent with ACC II's targets.[1329] The No-Action Alternatives also assume that manufacturers would make production decisions in response to estimated market demand for fuel economy or fuel efficiency, considering estimated fuel prices; estimated product development cadence; estimated availability, applicability, cost, and effectiveness of fuel-saving technologies; and available tax credits. The No-Action Alternatives further assume the applicability of recently passed tax credits for battery-based vehicle technologies, which improve the attractiveness of those technologies to consumers. The No-Action Alternatives provide a reference baseline (*i.e.,* an illustration of what would be occurring in the world in the absence of new Federal regulations) against which to compare the environmental impacts of other alternatives presented in the Draft and Final EIS.[1330]

[1317] "Unconstrained" modeling results are presented for comparison purposes only in some sections of the FRIA and accompanying databooks.

[1318] *Baltimore Gas & Elec. Co.* v. *Natural Resources Defense Council, Inc.,* 462 U.S. 87, 97 (1983).

[1319] *Robertson* v. *Methow Valley Citizens Council,* 490 U.S. 332, 350 (1989).

[1320] *See* 40 CFR 1505.2(a)(2). *Vermont Yankee Nuclear Power Corp.* v. *Nat. Res. Def. Council, Inc.,* 435 U.S. 519, 558 (1978).

[1321] Baltimore Gas, 462 U.S. at 97.

[1322] 42 U.S.C. 4332(2)(c)(iii).

[1323] *See* 40 CFR 1505.2(a)(2).

[1324] Under EPCA, as amended by EISA, NHTSA is required to set the fuel economy standards for passenger cars in each model year at the maximum feasible level and to do so separately for light trucks. Separately, and in accordance with EPCA, as amended by EISA, NHTSA is required to set FE standards for HDPUVs in each model year that are "designed to achieve the maximum feasible improvement" (49 U.S.C. 32902(k)(2)).

[1325] In its scoping notice, NHTSA indicated that the action alternatives analyzed would bracket a range of reasonable standards, allowing the agency to select an action alternative in its final rule from any stringency level within that range. 87 FR 50386, 50391 (Sept. 15, 2022).

[1326] Corporate Average Fuel Economy Standards for Model Years 2024–2026 Passenger Cars and Light Trucks; Final Rule, 87 FR 25710 (May 2, 2022). Revised 2023 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions Standards; Final Rule, 86 FR 74434 (Dec. 30, 2021).

[1327] In the last CAFE analysis, the No-Action Alternative also included five manufacturers' voluntary agreements with the State of California to achieve more stringent GHG standards through model year 2026. The stringency in the California Framework Agreement standards were superseded with EPA's revised GHG rule. Revised 2023 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions Standards; Final Rule, 86 FR 74434 (Dec. 30, 2021).

[1328] Greenhouse Gas Emissions Standards and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles; Final Rule, 76 FR 57106 (Sept. 15, 2011).

[1329] Section 177 of the CAA allows states to adopt motor vehicle emissions standards California has put in place to make progress toward attainment of national ambient air quality standards. At the time of writing, Colorado, Connecticut, Maine, Maryland, Massachusetts, New Jersey, New York, Oregon, Rhode Island, Vermont, and Washington have adopted California's ZEV program. See CARB. 2022. States that have Adopted California's Vehicle Standards under section 177 of the Federal CAA. Available at: *https://ww2.arb.ca.gov/resources/documents/states-have-adopted-californias-vehicle-standards-under-section-177-federal.* (Accessed: Feb. 28, 2024).

[1330] *See* 40 CFR 1502.2(e), 1502.14(d). CEQ has explained that "[T]he regulations require the analysis of the No-Action Alternative even if the

The range of CAFE and HDPUV FE standard action alternatives, as well as the relevant No-Action Alternative in the Final EIS, encompasses a spectrum of possible fuel economy and fuel efficiency standards that NHTSA could determine were maximum feasible based on the different ways NHTSA could weigh the applicable statutory factors. NHTSA analyzed five CAFE standard action alternatives, Alternative PC2LT002,[1331] Alternative PC1LT3, Alternative PC2LT4, Alternative PC3LT5, and Alternative PC6LT8 for passenger cars and light trucks, and four HDPUV FE standard action alternatives, Alternative HDPUV4,[1332] Alternative HDPUV108, Alternative HDPUV10, and Alternative HDPUV14 for HDPUVs. Under Alternative PC2LT002, fuel economy stringency would increase, on average, 2 percent per year, year over year for model year 2027–2031 passenger cars, and 0 percent increase per year, year over year for model year 2027–2028 light trucks, and 2 percent increase per year, year over year for model year 2029–2031 light trucks (Alternative PC2LT002 is NHTSA's Preferred Alternative for CAFE standards). Under Alternative PC1LT3, fuel economy stringency would increase, on average, 1 percent per year, year over year for model year 2027—2031 passenger cars, and 3 percent per year, year over year for model year 2027–2031 light trucks. Under Alternative PC2LT4, fuel economy stringency would increase, on average, 2 percent per year, year over year for model year 2027–2031 passenger cars, and 4 percent per year, year over year for model year 2027–2031 light trucks. Under Alternative PC3LT5, fuel economy stringency would increase, on average, 3 percent per year, year over year for model year 2027–2031 passenger cars, and 5 percent per year, year over year for model year 2027–2031 light trucks. Under Alternative PC6LT8, fuel economy stringency would increase, on average, 6 percent per year, year over year for model year 2027–2031 passenger cars, and 8 percent per year, year over year for model year 2027–2031 light trucks. Under Alternative HDPUV4, FE stringency would increase, on average, 4 percent per year, year over year, for model year 2030–2035 HDPUVs. Under Alt. HDPUV108, FE stringency would increase, on average, 10 percent per year, year over year for model year 2030–2032 and 8 percent per year, year over year for model year 2033–2035 HDPUVs (Alt. HDPUV108 is NHTSA's Preferred Alternative for HDPUV FE standards). Under HDPUV10, FE stringency would increase, on average, 10 percent per year, year over year, for model year 2030–2035 HDPUVs (Alternative HDPUV10 is NHTSA's Preferred Alternative for HDPUV FE standards). Under Alternative HDPUV14, FE stringency would increase on average, 14 percent per year, year over year for model year 2030–2035 HDPUVs. NHTSA also analyzed three CAFE and HDPUV FE alternative combinations for the cumulative impacts analysis, Alternatives PC2LT002 and HDPUV4 (the least stringent and highest fuel-use CAFE and HDPUV FE standard action alternatives), Alternatives PC2LT002 and HDPUV108 (the Preferred CAFE and HDPUV FE alternatives), and Alternatives PC6LT8 and HDPUV14 (the most stringent and lowest fuel-use CAFE and HDPUV FE standard action alternatives). The primary differences between the action alternatives considered for the Draft EIS and the Final EIS is that the Final EIS added an alternative, Alternative PC2LT002 for CAFE standard and Alternative HDPUV108 for HDPUV FE standard. Both of the ranges of action alternatives, as well as the No-Action alternative, in the Draft EIS and Final EIS encompassed a spectrum of possible standards the agency could determine was maximum feasible, or represented the maximum feasible improvement for HDPUVs, based on the different ways the agency could weigh EPCA's four statutory factors. Throughout the Final EIS, estimated impacts were shown for all of these action alternatives, as well as for the relevant No-Action Alternative. For a more detailed discussion of the environmental impacts associated with the alternatives, see Chapters 3–8 of the EIS, as well as Section IV.C of this preamble.

The agency's Final EIS describes potential environmental impacts to a variety of resources, including fuel and energy use, air quality, climate, EJ, and historic and cultural resources. The EIS also describes how climate change resulting from global GHG emissions (including CO_2 emissions attributable to the U.S. LD transportation sector under the alternatives considered) could affect certain key natural and human resources. Resource areas are assessed qualitatively and quantitatively, as appropriate, in the Final EIS, and the findings of that analysis are summarized here. As explained above, the qualitative impacts presented below come from the EIS' ''unconstrained'' modeling so that NHTSA is appropriately informed about the potential environmental impacts of this action. Qualitative discussions of impacts related to life-cycle assessment of vehicle materials, EJ, and historic and cultural resources are located in the EIS, while the impacts summarized here focus on energy, air quality, and climate change.

1. Environmental Consequences

a. Energy

(1) Direct and Indirect Impacts

As the stringency of the CAFE standard alternatives increases, total U.S. passenger car and light truck fuel consumption for the period of 2022 to 2050 decreases. Total LD vehicle fuel consumption from 2022 to 2050 under the CAFE No-Action Alternative is projected to be 2,774 billion gasoline gallon equivalents (GGE). LD vehicle fuel consumption from 2022 to 2050 under the action alternatives is projected to range from 2,760 billion GGE under Alternative PC2LT002 to 2,596 billion GGE under Alternative PC6LT8. Under Alternative AlternativePC1LT3, LD vehicle fuel consumption from 2022 to 2050 is projected to be 2,736 billion GGE. Under Alternative PC2LT4, LD vehicle fuel consumption from 2022 to 2050 is projected to be 2,729 billion GGE. Under Alternative PC3LT5, LD vehicle fuel consumption from 2022 to 2050 is projected to be 2,695 billion GGE. All of the CAFE standard action alternatives would decrease fuel consumption compared to the relevant No-Action Alternative, with fuel consumption decreases that range from 14 billion GGE under Alternative PC2LT002 to 179 billion GGE under Alternative PC6LT8. For the preferred alternative, fuel consumption decreases by 14 billion GGE.

As the stringency of the HDPUV FE standard alternatives increases, total U.S. HDPUV fuel consumption for the period of 2022 to 2050 decreases. Total

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agency is under a court order or legislative command to act. This analysis provides a benchmark, enabling decision makers to compare the magnitude of environmental effects of the action alternatives [*See* 40 CFR 1502.14(c).] . . . Inclusion of such an analsyis in the EIS is necessary to inform Congress, the public, and the President as intended by NEPA. [*See* 40 CFR 1500.1(a).]'' Forty Most Asked Questions Concerning CEQ's NEPA Regulations, 46 FR 18026 (Mar. 23, 1981).

[1331] The abbreviation PC2LT002 is meant to reflect a 2 percent increase for passenger cars, a 0 percent increase for light trucks for model year 2027–2028, and a 2 percent increase for light trucks, including SUVs, for model year 2029–2031. PC2LT002 is formatted differently than the other CAFE alternatives because the rate of stringency increase changes across years, whereas in the other alternatives, the rate of increase is constant year over year.

[1332] The abbreviation HDPUV4 is meant to reflect a 4 percent increase for HDPUVs. The abbreviation for each HDPUV action alternative uses the same naming convention.

HDPUV vehicle fuel consumption from 2022 to 2050 under the No-Action Alternative is projected to be 418.9 billion GGE. HDPUV fuel consumption from 2022 to 2050 under the action alternatives is projected to range from 418.6 billion GGE under Alternative HDPUV4 to 401.9 billion GGE under Alternative HDPUV14. Under Alternative HDPUV108, HDPUV vehicle fuel consumption from 2022 to 2050 is projected to be 415 billion GGE. Under Alternative HDPUV10, HDPUV vehicle fuel consumption from 2022 to 2050 is projected to be 412 billion GGE. All of the HDPUV standard action alternatives would decrease fuel consumption compared to the relevant No-Action Alternative, with fuel consumption decreases that range from 0.3 billion GGE under Alternative HDPUV4 to 17.0 billion GGE under HDPUV14. For the preferred alternative, fuel consumption decreases by 4 billion GGE.

(2) Cumulative Impacts

Energy cumulative impacts are composed of both LD and HDPUV energy use in addition to other past, present, and reasonably foreseeable future actions. As the CAFE Model includes many foreseeable trends, NHTSA examined two AEO 2023 side cases that could proxy a range of future outcomes where oil consumption is lower based on a range of macroeconomic factors. Since the results of the CAFE and HDPUV FE standards are a decline in oil consumption, examining side cases that also result in lower oil consumption while varying macroeconomic factors provides some insights into the cumulative effects of CAFE standards paired with other potential future events. Energy production and consumption from those side cases is presented in comparison to the AEO 2023 reference case qualitatively in the EIS. Below, we present the combined fuel consumption savings from the LD CAFE and HDPUV FE standards. These results also include impacts from the model year 2032 augural year standard that the agency is setting forth.

Total LD vehicle and HDPUV fuel consumption from 2022 to 2050 under the No-Action Alternatives is projected to be 3,193 billion GGE. LD vehicle and HDPUV fuel consumption from 2022 to 2050 under the action alternatives is projected to range from 3,178 billion GGE under Alternatives PC2LT002 and HDPUV4 to 2,955 billion GGE under Alternatives PC6LT8 and HDPUV14. Under Alternatives PC2LT002 and HDPUV108, the total LD vehicle and HDPUV fuel consumption from 2022 to 2050 is projected to be 3,174 billion GGE. All of the action alternatives would decrease fuel consumption compared to the No-Action Alternatives, with decreases ranging from 15 billion GGE under Alternatives PC2LT002 and HDPUV4 to 238 billion GGE under Alternatives PC6LT8 and HDPUV14. For the preferred alternatives, fuel consumption decreases by 19 billion GGE.

Changing CAFE and HDPUV FE standards are expected to reduce gasoline and diesel fuel use in the transportation sector but are not expected to have any discernable effect on energy consumption by other sectors of the U.S. economy because petroleum products account for a very small share of energy use in other sectors. Gasoline and diesel (distillate fuel oil) account for less than 5 percent of energy use in the industrial sector, less than 4 percent of energy use in the commercial building sector, 2 percent of energy use in the residential sector, and only about 0.2 percent of energy use in the electric power sector.

b. Air Quality

(1) Direct and Indirect Impacts

The relationship between stringency and criteria and air toxics pollutant emissions is less straightforward than the relationship between stringency and energy use, because it reflects the complex interactions among the vehicle-based emissions rates of the various vehicle types (passenger cars and light trucks, HDPUVs, ICE vehicles and EVs, older and newer vehicles, etc.), the technologies assumed to be incorporated by manufacturers in response to CAFE and HDPUV FE standards, upstream emissions rates, the relative proportions of gasoline, diesel, and electricity in total fuel consumption, and changes in VMT from the rebound effect. In general, emissions of criteria air pollutants decrease, with some exceptions, in both the short and long term. The decreases get larger as the stringency increases across action alternatives, with some exceptions. In general, emissions of toxic air pollutants remain the same or decrease in both the short and long term. The decreases stay the same or get larger as the stringency increases across action alternatives, with some exceptions. In addition, the action alternatives would result in decreased incidence of $PM_{2.5}$-related health impacts in most years and alternatives due to the emissions decreases. Decreases in adverse health impacts include decreased incidences of premature mortality, acute bronchitis, respiratory emergency room visits, and work-loss days.

(a) Criteria Pollutants

In 2035, emissions of CO, NO_X, $PM_{2.5}$, and VOCs decrease under all CAFE standard action alternatives compared to the CAFE No-Action Alternative, while emissions of SO_2 increase. Relative to the No-Action Alternative, the modeling results suggest CO, NO_X, $PM_{2.5}$, and VOC emissions decreases in 2035 that get larger from Alternative PC2LT002 through Alternative PC6LT8. There are also increases in SO_2 emissions that reflect the projected increase in EV use in the later years. However, note that modeled increases are very small relative to reductions from the historical levels.

In 2050, emissions of CO, NO_X, $PM_{2.5}$, and VOCs decrease under all CAFE standard action alternatives compared to the CAFE No-Action Alternative. Relative to the No-Action Alternative, the modeling results suggest CO, NO_X, $PM_{2.5}$, and VOC emissions decreases in 2050 that get larger from Alternative PC2LT002 to Alternative PC1LT3, and from Alternative PC2LT4 through Alternative PC6LT8, but the decreases get smaller from Alternative PC1LT3 to PC2LT4. Emissions of SO_2 increase under all CAFE standard action alternatives, except for Alternative PC2LT4, compared to the CAFE No-Action Alternative, and the increases get larger from Alternative PC2LT002 to Alternative PC1LT3 and from Alternative PC3LT5 to Alternative PC6LT8. In 2050, as in 2035, the increases in SO_2 emissions reflect the projected increase in EV use in the later years. Further, any modeled increases were very small relative to reductions from the historical levels represented in the current CAFE standard. Under each CAFE standard action alternative compared to the CAFE No-Action Alternative, the largest relative increases in emissions among the criteria pollutants would occur for SO_2, for which emissions would increase by as much as 3.0 percent under Alternative PC6LT8 in 2050 compared to the CAFE No-Action Alternative. The largest relative decreases in emissions would occur for CO, for which emissions would decrease by as much as 18.3 percent under Alternative PC6LT8 in 2050 compared to the CAFE No-Action Alternative. Percentage increases and decreases in emissions of NO_X, $PM_{2.5}$, and VOCs would be less. The smaller differences are not expected to lead to measurable changes in concentrations of criteria pollutants in the ambient air. The larger differences in emissions could lead to changes in ambient pollutant concentrations.

In 2035 and 2050, emissions of SO_2 increase under the HDPUV FE standard action alternatives compared to the HDPUV FE No-Action Alternative, while emissions of CO, NO_X, $PM_{2.5}$, and VOCs decrease. Relative to the HDPUV FE No-Action Alternative, the modeling results suggest SO_2 emissions increases get larger from Alternative HDPUV4 through Alternative HDPUV14. The increases in SO_2 emissions reflect the projected increase in EV use in the later years. Further, any modeled increases were very small relative to reductions from the historical levels represented in the current HDPUV FE standard. For CO, NO_X, $PM_{2.5}$, and VOCs, the emissions decreases get larger from Alternative HDPUV4 through Alternative HDPUV14 relative to the No-Action Alternative.

Under each HDPUV FE standard action alternative compared to the HDPUV FE No-Action Alternative, the largest relative increases in emissions among the criteria pollutants would occur for SO_2, for which emissions would increase by as much as 6.7 percent under Alternative HDPUV14 in 2050 compared to the No-Action Alternative. The largest relative decreases in emissions would occur for CO, for which emissions would decrease by as much as 13.5 percent under Alternative HDPUV14 in 2050 compared to the No-Action Alternative. Percentage reductions in emissions of NO_X, $PM_{2.5}$, and VOCs would be less, though the reductions in VOCs in 2035 (by as much as 3.3 percent under Alternative HDPUV14) would be greater than those of CO in 2035 (by as much as 1.7 percent under Alternative HDPUV14). The smaller differences are not expected to lead to measurable changes in concentrations of criteria pollutants in the ambient air. The larger differences in emissions could lead to changes in ambient pollutant concentrations.

(b) Toxic Air Pollutants

Under each CAFE standard action alternative in 2035 and 2050 relative to the CAFE No-Action Alternative, emissions would remain the same or decrease for all toxic air pollutants. The decreases stay the same or get larger from Alternative PC2LT002 through Alternative PC6LT8, except that for acetaldehyde, acrolein, 1,3-butadiene, and formaldehyde for which emissions would decrease by as much as 23 percent under Alternative PC6LT8 in 2050 compared to the CAFE No-Action Alternative. Percentage decreases in emissions of benzene and DPM would be less. The smaller differences are not expected to lead to measurable changes in concentrations of toxic air pollutants in the ambient air. For such small changes, the impacts of those action alternatives would be essentially equivalent. The larger differences in emissions could lead to changes in ambient pollutant concentrations.

Under each HDPUV FE standard action alternative in 2035 and 2050 relative to the HDPUV FE No-Action Alternative, emissions either remain the same or decrease for all toxic air pollutants. The decreases get larger from Alternative HDPUV4 through Alternative HDPUV14. The largest relative decreases in national emissions of toxic air pollutants among the HDPUV FE standard action alternatives, compared to the HDPUV FE No-Action Alternative, generally would occur for 1,3-butadiene and formaldehyde for which emissions would decrease by as much as 14.5 percent under Alternative HDPUV14 in 2050 compared to the HDPUV FE No-Action Alternative. The largest percentage decreases in emissions of acetaldehyde, acrolein, and benzene would be similar, decreasing as much as 13.6 to 14.2 percent under Alternative HDPUV14 in 2050 compared to the No-Action Alternative. Percentage decreases in emissions of DPM would be less, in some cases less than 1 percent. The smaller differences are not expected to lead to measurable changes in concentrations of toxic air pollutants in the ambient air. For such small changes, the impacts of those action alternatives would be essentially equivalent. The larger differences in emissions could lead to changes in ambient pollutant concentrations.

(c) Health Impacts

In 2035 and 2050, all CAFE standard action alternatives would result in decreases in adverse health impacts (mortality, acute bronchitis, respiratory emergency room visits, and other health effects) nationwide compared to the CAFE No-Action Alternative, due to decreases in downstream emissions, particularly of $PM_{2.5}$. The improvements to health impacts (or decreases in health incidences) would stay the same or get larger from Alternative PC2LT002 to Alternative PC6LT8 in 2035 and 2050, except that in 2050 the decrease from Alternative PC1LT3 to Alternative PC2LT4 is smaller. These decreases reflect the generally increasing stringency of the action alternatives as they become implemented.

In 2035 and 2050, all HDPUV FE standard action alternatives would decrease adverse health impacts nationwide compared to the HDPUV FE No-Action Alternative. The improvements to health impacts (or decreases in health incidences) would get larger from Alternative HDPUV4 to Alternative HDPUV14 in 2035 and 2050.

(2) Cumulative Impacts

(a) Criteria Pollutants

In 2035 and 2050, emissions of SO_2 increase under the CAFE and HDPUV FE alternative combinations compared to the No-Action Alternatives, while emissions of CO, NO_X, $PM_{2.5}$, and VOCs decrease. However, any modeled increases are very small relative to reductions from the historical levels represented in the current CAFE and HDPUV FE standards. Relative to the No-Action Alternatives, the modeling results suggest SO_2 emissions increases that get larger with increasing stringency of alternative combinations compared to the No-Action Alternatives. For CO, NO_X, $PM_{2.5}$, and VOCs, the emissions decreases get larger with increasing stringency of alternative combinations compared to the No-Action Alternatives.

Under each CAFE and HDPUV FE alternative combination compared to the No-Action Alternatives, the largest relative increases in emissions among the criteria pollutants would occur for SO_2, for which emissions would increase by as much as 5.2 percent under Alternatives PC6LT8 and HDPUV14 in 2050, compared to the No-Action Alternatives. The largest relative decreases in emissions would occur for CO, for which emissions would decrease by as much as 24 percent under Alternatives PC6LT8 and HDPUV14 in 2050, compared to the No-Action Alternatives. Percentage decreases in emissions of NO_X, $PM_{2.5}$, and VOCs would be less, though reductions in $PM_{2.5}$ in 2035 (by as much as 4.1 percent under Alternatives PC6LT8 and HDPUV14) and VOCs in 2035 (by as much as 6.1 percent under Alternatives PC6LT8 and HDPUV14) would be greater than those of CO in 2035 (by as much as 3.7 percent under Alternatives PC6LT8 and HDPUV14). The smaller differences are not expected to lead to measurable changes in concentrations of criteria pollutants in the ambient air. The larger differences in emissions could lead to changes in ambient pollutant concentrations.

(b) Toxic Air Pollutants

Toxic air pollutant emissions across the CAFE and HDPUV FE alternative combinations decrease in 2035 and 2050, relative to the No-Action Alternatives. The decreases remain the same or get larger with increasing stringency of alternative combinations. The largest relative decreases in emissions generally would occur for 1,3-butadiene and formaldehyde for which emissions would decrease by as much as 28 percent under Alternatives PC6LT8 and HDPUV14 in 2050, compared to the No-Action Alternatives. The largest percentage decreases in emissions of acetaldehyde, acrolein, and benzene would be similar, decreasing as much as 26 to 27 percent under Alternatives PC6LT8 and HDPUV14 in 2050 compared to the No-Action Alternative. Percentage decreases in emissions of DPM would be less.

(c) Health Impacts

Adverse health impacts (mortality, acute bronchitis, respiratory emergency room visits, and other health effects) from criteria pollutant emissions would decrease nationwide in 2035 and 2050 under all CAFE and HDPUV FE alternative combinations, relative to the No-Action Alternatives. The improvements to health impacts (or decreases in health incidences) in 2035 and 2050 would stay the same or get larger from Alternatives PC2LT002 and HDPUV4 to Alternatives PC6LT8 and HDPUV14. These decreases reflect the generally increasing stringency of the CAFE and HDPUV FE standard action alternatives as they become implemented.

As mentioned above, changes in assumptions about modeled technology adoption; the relative proportions of gasoline, diesel, and other fuels in total fuel consumption changes; and changes in VMT from the rebound effect would alter these health impact results; however, NHTSA believes that assumptions employed in the modeling supporting these final standards are reasonable.

c. Greenhouse Gas Emissions and Climate Change

(1) Direct and Indirect Impacts

In terms of climate effects, the action alternatives would decrease both U.S. passenger car and light truck and HDPUV fuel consumption and CO_2 emissions compared with the relevant No-Action Alternative, resulting in reductions in the anticipated increases in global CO_2 concentrations, temperature, precipitation, sea level, and ocean acidification that would otherwise occur. They would also, to a small degree, reduce the impacts and risks associated with climate change. The impacts of the action alternatives on atmospheric CO_2 concentration, global mean surface temperature, precipitation, sea level, and ocean pH would be small in relation to global emissions trajectories. Although these effects are small, they occur on a global scale and are long lasting; therefore, in aggregate, they can have large consequences for health and welfare and can make an important contribution to reducing the risks associated with climate change.

(a) Greenhouse Gas Emissions

The CAFE standard action alternatives would have the following impacts related to GHG emissions: Passenger cars and light trucks are projected to emit 46,500 million metric tons of carbon dioxide ($MMTCO_2$) from 2027 through 2100 under the CAFE No-Action Alternative. Compared to the No-Action Alternative, projected emissions reductions from 2027 to 2100 under the CAFE standard action alternatives would range from 400 to 7,000 $MMTCO_2$. Under Alternative PC2LT002, emissions reductions from 2027 to 2100 are projected to be 400 $MMTCO_2$. The CAFE standard action alternatives would reduce total CO_2 emissions from U.S. passenger cars and light trucks by a range of 0.9 to 15.1 percent from 2027 to 2100 compared to the CAFE No-Action Alternative. Alternative PC2LT002 would decrease these emissions by less than 1 percent through 2100. All CO_2 emissions estimates associated with the CAFE standard action alternatives include upstream emissions.

The HDPUV FE standard action alternatives would have the following impacts related to GHG emissions: HDPUVs are projected to emit 9,700 $MMTCO_2$from 2027 through 2100 under the HDPUV FE No-Action Alternative. Compared to the No-Action Alternative, projected emissions reductions from 2027 to 2100 under the HDPUV action alternatives would range from 0 to 1,100 $MMTCO_2$. Under Alternative HDPUV108, emissions reductions from 2027 to 2100 are projected to be 300 $MMTCO_2$. The HDPUV FE standard action alternatives would decrease these emissions by a range of 0.0 to 11.3 percent from 2027 to 2100 compared to the HDPUV FE No-Action Alternative. Alternative HDPUV108 would decrease these emissions by 3.1 percent through 2100. All CO_2 emissions estimates associated with the HDPUV FE standard action alternatives include upstream emissions.

Compared with total projected CO_2 emissions of 468 $MMTCO_2$ from all passenger cars and light trucks under the CAFE No-Action Alternative in the year 2100, the CAFE standard action alternatives are expected to decrease CO_2 emissions from passenger cars and light trucks in the year 2100 by 2 percent under Alternative PC1LT3, less than 2 percent under Alternative PC2LT4, 6 percent under Alternative PC3LT5, and 19 percent under Alternative PC6LT8. Under Alternative PC2LT002, the 2100 total projected CO_2 emissions for all passenger cars and light trucks are 464 $MMTCO_2$, reflecting a 1 percent decrease.

Compared with total projected CO_2 emissions of 116 $MMTCO_2$ from all HDPUVs under the HDPUV FE No-Action Alternative in the year 2100, the HDPUV FE standard action alternatives are expected to decrease CO_2 emissions from HDPUVs in the year 2100 by a range of less than 1 percent under Alternative HDPUV4 to 13 percent under Alternative HDPUV14. Under Alternative HDPUV108, the 2100 total projected CO_2 emissions for all HDPUVs are 112 $MMTCO_2$, reflecting a 4 percent decrease.

To estimate changes in CO_2 concentrations and global mean surface temperature, NHTSA used a reduced-complexity climate model (MAGICC). The reference scenario used in the direct and indirect analysis is the SSP3–7.0 scenario, which the Intergovernmental Panel on Climate Change (IPCC) describes as a high emissions scenario that assumes no successful, comprehensive global actions to mitigate GHG emissions and yields atmospheric CO_2 levels of 800 ppm and an effective radiative forcing (ERF) of 7.0 watts per square meter (W/m^2) in 2100. Compared to the SSP3–7.0 total U.S. emissions projection of 619,064 MMTCO2 under the CAFE No-Action Alternative from 2027 to 2100, the CAFE standard action alternatives are expected to reduce U.S. emissions by .06 percent under Alternative PC2LT002, 0.18 percent under Alternative PC1LT3, 0.16 percent under Alternative PC2LT4, 0.40 percent under Alternative PC3LT5, and 1.13 percent under Alternative PC6LT8 by 2100. Global emissions would also be reduced to a lesser extent. Compared to SSP3–7.0 total global CO_2 emissions projection of 4,991,547 $MMTCO_2$ under the CAFE No-Action Alternative from 2027 through 2100, the CAFE standard action alternatives are expected to reduce global CO_2 by 0.01 percent under Alternative PC2LT002, 0.02 percent under Alternative PC1LT3, 0.02 percent under Alternative PC2LT4, 0.05 percent under Alternative PC3LT5, and 0.14 percent under Alternative PC6LT8 by 2100. Additional information about the range of alternatives' emissions decreases compared to U.S. emissions projections is located in Chapter 5 of the Final EIS.

Compared to the SSP3–7.0 total U.S. emissions projection of 619,064

MMTCO2 under the HDPUV No-Action Alternative from 2027 to 2100, the HDPUV standard action alternatives are expected to reduce U.S. emissions by 0.00 percent under Alternative HDPUV4, 0.05 percent under Alternative HDPUV108, 0.08 percent under Alternative HDPUV10, and 0.18 percent under Alternative HDPUV14 by 2100. Global emissions would also be reduced to a lesser extent. Compared to SSP3–7.0 total global CO_2 emissions projection of 4,991,547 $MMTCO_2$ under the HDPUV No-Action Alternative from 2027 through 2100, the HDPUV action alternatives are expected to reduce global CO_2 by less than 0.01 percent under Alternative HDPUV4, 0.01 percent under Alternative HDPUV108, 0.01 percent under Alternative HDPUV10, and 0.02 percent under Alternative HDPUV14 by 2100.

The emissions reductions from all passenger cars and light trucks in 2035 compared with emissions under the CAFE No-Action Alternative are approximately equivalent to the annual emissions from 2,282,379 vehicles under Alternative PC2LT002 to 25,343,679 passenger cars and light trucks (Alternative PC6LT8) in 2035, compared to the annual emissions under the No-Action Alternative. A total of 260,932,626 passenger cars and light trucks are projected to be on the road in 2035 under the No-Action Alternative.[1333] The emissions reductions from HDPUVs in 2032 compared with emissions under the HDPUV FE No-Action Alternative are approximately equivalent to the annual emissions from 16,180 HDPUVs (Alternative HDPUV4) to 785,474 HDPUVs (Alternative HDPUV14) in 2035, compared to the annual emissions under the No-Action Alternative. A total of 18,299,639 HDPUVs are projected to be on the road in 2035 under the No-Action Alternative.[1334]

(b) Climate Change Indicators (Carbon Dioxide Concentration, Global Mean Surface Temperature, Sea Level, Precipitation, and Ocean pH)

CO_2 emissions affect the concentration of CO_2 in the atmosphere, which in turn affects global temperature, sea level, precipitation, and ocean pH. For the analysis of direct and indirect impacts, NHTSA used the SSP3–7.0 scenario to represent the reference case emissions scenario (*i.e.,* future global emissions assuming no comprehensive global actions to mitigate GHG emissions). NHTSA selected the SSP3–7.0 scenario for its incorporation of a comprehensive suite of GHG and pollutant gas emissions, including carbonaceous aerosols and a global context of emissions with a full suite of GHGs and ozone precursors.

The CO_2 concentrations under the SSP3–7.0 emissions scenario in 2100 are estimated to be 838.31 ppm under the CAFE No-Action Alternative. CO_2 concentrations under the CAFE standard action alternatives could reach 837.65 ppm under Alternative PC6LT8, indicating a maximum atmospheric CO_2 decrease of approximately 0.67 ppm compared to the CAFE No-Action Alternative. Atmospheric CO_2 concentrations under Alternative PC2LT002 would decrease by 0.04 ppm compared with the CAFE No-Action Alternative. Under the HDPUV FE standard action alternatives, CO_2 concentrations under the SSP3–7.0 emissions scenario in 2100 are estimated to decrease to 838.21 ppm under Alternative HDPUV14, indicating a maximum atmospheric CO_2 decrease of approximately 0.10 ppm compared to the HDPUV FE No-Action Alternative. Atmospheric CO_2 concentrations under Alternative HDPUV108 would decrease by 0.03 ppm compared with the HDPUV FE No-Action Alternative.

Under the SSP3–7.0 emissions scenario, global mean surface temperature is projected to increase by approximately 4.34 °C (7.81 °F) under the CAFE No-Action Alternative by 2100. Implementing the most stringent alternative (Alternative PC6LT8) would decrease this projected temperature rise by 0.003 °C (0.005 °F), while Alternative PC2LT002 would decrease the projected temperature rise by 0.001 °C (0.002 °F).

Under the SSP3–7.0 emissions scenario, global mean surface temperature is projected to increase by approximately 4.34 °C (7.81 °F) under the HDPUV FE No-Action Alternative by 2100. The range of temperature increases under the HDPUV FE standard action alternatives would decrease this projected temperature rise by a range of less than 0.0001 °C (0.0002 °F) under Alternative HDPUV4 to 0.0004 °C (0.0007 °F) under Alternative HDPUV14.

Under the CAFE standard action alternatives, projected sea-level rise in 2100 under the SSP3–7.0 scenario ranges from a high of 83.24 centimeters (32.77 inches) under the CAFE No-Action Alternative to a low of 83.19 centimeters (32.75 inches) under Alternative PC6LT8. Alternative PC6LT8 would result in a decrease in sea-level rise equal to 0.06 centimeter (0.02 inch) by 2100 compared with the level projected under the CAFE No-Action Alternative. Alternative PC2LT002 would result in a decrease of less than 0.01 centimeter (0.004 inch) compared with the CAFE No-Action Alternative. Under the HDPUV FE standard action alternatives, projected sea-level rise in 2100 under the SSP3–7.0 scenario varies less than 0.01 centimeter (0.004 inch) under Alternative HDPUV14 from a high of 83.24 centimeters (32.77 inches) under HDPUV FE No-Action Alternative. Under the SSP3–7.0 scenario, global mean precipitation is anticipated to increase by 7.42 percent by 2100 under the CAFE No-Action Alternative. Under the CAFE standard action alternatives, this increase in precipitation would be reduced by less than 0.01 percent.

Under the SSP3–7.0 scenario, global mean precipitation is anticipated to increase by 7.42 percent by 2100 under the HDPUV FE No-Action Alternative. HDPUV FE standard action alternatives would see a reduction in precipitation of less than 0.01 percent.

Under the SSP3–7.0 scenario, ocean pH in 2100 is anticipated to be 8.1936 under Alternative PC6LT8, about 0.0003 more than the CAFE No-Action Alternative. Under Alternative PC2LT002, ocean pH in 2100 would be 8.1933, or less than 0.0001 more than the CAFE No-Action Alternative.

Under the SSP3–7.0 scenario, ocean pH in 2100 is anticipated to be 8.1933 under Alternative HDPUV108, or less than 0.0001 more than the HDPUV FE No-Action Alternative.

The action alternatives for both CAFE and HDPUV FE standards would reduce the impacts of climate change that would otherwise occur under the No-Action Alternative. Although the projected reductions in CO_2 and climate effects are small compared with total projected future climate change, they are quantifiable and directionally consistent and would represent an important contribution to reducing the risks associated with climate change.

(2) Cumulative Impacts

(a) Greenhouse Gas Emissions

For the analysis of cumulative impacts, NHTSA used the SSP2–4.5 scenario to represent a reference case global emissions scenario that assumes a moderate level of global actions to address climate change and predicts CO_2 emissions would remain around

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[1333] Values for vehicle totals have been rounded. The passenger car and light truck equivalency is based on an average per-vehicle emissions estimate, which includes both tailpipe CO_2 emissions and associated upstream emissions from fuel production and distribution. The average passenger car and light truck is projected to account for 3.94 metric tons of CO_2 emissions in 2035 based on MOVES, the GREET model, and EPA analysis.

[1334] Values for vehicle totals have been rounded. The average HDPUV is projected to account for 8.46 metric tons of CO_2 emissions in 2035 based on MOVES, the GREET model, and EPA analysis.

current levels before starting to fall mid-century. The IPCC refers to SSP2–4.5 as an intermediate emissions scenario. NHTSA chose this scenario as a plausible global emissions baseline for the cumulative analysis because of the potential impacts of these reasonably foreseeable actions, yielding a moderate level of global GHG reductions from the SSP3–7.0 baseline scenario used in the direct and indirect analysis.

The CAFE and HDPUV alternative combinations would have the following impacts related to GHG emissions: Projections of total emissions reductions from 2027 to 2100 under the CAFE and HDPUV alternative combinations and other reasonably foreseeable future actions compared with the No-Action Alternatives range from 500 $MMTCO_2$ under Alternatives PC2LT002 and HDPUV4 to 10,500 $MMTCO_2$ under Alternatives PC6LT8 and HDPUV14. Under Alternatives PC2LT002 and HDPUV108, emissions reductions from 2027 to 2100 are projected to be 800 $MMTCO_2$. The action alternatives would decrease total vehicle emissions by between 0.9 percent under Alternatives PC2LT002 and HDPUV4 and 18.7 percent under Alternatives PC6LT8 and HDPUV14 by 2100. Alternatives PC2LT002 and HDPUV108 would decrease these emissions by 1.4 percent over the same period. Compared with projected total global CO_2 emissions of 2,484,191 $MMTCO_2$ from all sources from 2027 to 2100 using the moderate climate scenario, the incremental impact of this rulemaking is expected to decrease global CO_2 emissions between 0.01 percent under Alternatives PC2LT002 and HDPUV4 and 0.21 percent under Alternatives PC6LT8 and HDPUV14 by 2100. Alternatives PC2LT002 and HDPUV108 would decrease these emissions by 0.02 percent over the same period.

(b) Climate Change Indicators (Carbon Dioxide Concentration, Global Mean Surface Temperature, Sea Level, Precipitation, and Ocean pH)

Estimated atmospheric CO_2 concentrations in 2100 range from 587.78 ppm under the No-Action Alternatives to 586.89 ppm under Alternatives PC6LT8 and HDPUV14 (the combination of the most stringent CAFE and HDPUV FE standard alternatives). This is a decrease of 0.89 ppm compared with the No-Action Alternatives.

Global mean surface temperature decreases for the CAFE and HDPUV alternative combinations compared with the No-Action Alternatives in 2100 range from a low of less than 0.0001 °C (0.002 °F) under Alternatives PC2LT002 and HDPUV4 to a high of 0.0042 °C (0.007 °F) under Alternatives PC6LT8 and HDPUV14.

Global mean precipitation is anticipated to increase 6.11 percent under the No-Action Alternatives, with the CAFE and HDPUV alternative combinations reducing this effect up to 0.01 percent.

Projected sea-level rise in 2100 ranges from a high of 67.12 centimeters (26.42 inches) under the No-Action Alternatives to a low of 67.03 centimeters (26.39 inches) under Alternatives PC6LT8 and HDPUV14, indicating a maximum decrease in projected sea-level rise of 0.08 centimeter (0.03 inch) by 2100.

Ocean pH in 2100 is anticipated to be 8.3334 under Alternatives PC6LT8 and HDPUV14, about 0.0006 more than the No-Action Alternatives.

(c) Health, Societal, and Environmental Impacts of Climate Change

The Proposed Action and action alternatives would reduce the impacts of climate change that would otherwise occur under the No-Action Alternatives. The magnitude of the changes in climate effects that would be produced by the most stringent action alternatives combination (Alternatives PC6LT8 and HDPUV14) using the three-degree sensitivity analysis by the year 2100 is 0.89 ppm lower concentration of CO_2, a four-thousandths-of-a-degree decrease in the projected temperature rise, a small percentage change in precipitation increase, a 0.08 centimeter (0.03 inch) decrease in projected sea-level rise, and an increase of 0.0006 in ocean pH. Although the projected reductions in CO_2 and climate effects are small compared with total projected future climate change, they are quantifiable, directionally consistent, and would represent an important contribution to reducing the risks associated with climate change. As discussed below, one significant risk associated with climate change is reaching a level of atmospheric greenhouse gas concentrations that cause large-scale, abrupt changes in the climate system and lead to significant impacts on human and natural systems. We do not know what level of atmospheric concentrations will trigger a tipping point—only that the risk increases significantly as concentrations rise. As such, even the relatively small reductions achieved by this rule could turn out to be the reductions that avoid triggering a tipping point, and thereby avoid the highly significant deleterious climate impacts that would have followed.

Although NHTSA does quantify the changes in monetized damages that can be attributable to each action alternative with its use of the social cost of carbon metric, many specific impacts of climate change on health, society, and the environment cannot be estimated quantitatively. Economists have estimated the incremental effect of GHG emissions, and monetized those effects, to express the social costs of carbon, CH_4, and N_2O in terms of dollars per ton of each gas. By multiplying the emissions reductions of each gas by estimates of their social cost, NHTSA derived a monetized estimate of the benefits associated with the emissions reductions projected under each action alternative. NHTSA has estimated the monetized benefits associated with GHG emissions reductions in its Final Regulatory Impact Analysis Chapter 6.5.1. See Chapter 6.2.1 of the Technical Support Document (TSD) for a description of the methods used for these estimates.

NHTSA also provides a qualitative discussion of these impacts by presenting the findings of peer-reviewed panel reports including those from IPCC, the Global Change Research Program (GCRP), the Climate Change Science Program (CCSP), the National Resource Council (NRC), and the Arctic Council, among others. While the action alternatives would decrease growth in GHG emissions and reduce the impact of climate change across resources relative to the No-Action Alternative, they would not themselves prevent climate change and associated impacts. Long-term climate change impacts identified in the scientific literature are briefly summarized below, and vary regionally, including in scope, intensity, and directionality (particularly for precipitation). While it is difficult to attribute any particular impact to emissions that could result from this rulemaking, the following impacts are likely to be beneficially affected to some degree by reduced emissions from the action alternatives:

- *Freshwater Resources:* Projected risks to freshwater resources are expected to increase due to changing temperature and precipitation patterns as well as the intensification of extreme events like floods and droughts, affecting water security in many regions of the world and exacerbating existing water-related vulnerabilities.
- *Terrestrial and Freshwater Ecosystems:* Climate change is affecting terrestrial and freshwater ecosystems, including their component species and the services they provide. This impact can range in scale (from individual to population to species) and can affect all aspects of an organism's life, including

its range, phenology, physiology, and morphology.

- *Ocean Systems, Coasts, and Low-Lying Areas:* Climate change-induced impacts on the physical and chemical characteristics of oceans (primarily through ocean warming and acidification) are exposing marine ecosystems to unprecedented conditions and adversely affecting life in the ocean and along its coasts. Anthropogenic climate change is also worsening the impacts on non-climatic stressors, such as habitat degradation, marine pollution, and overfishing.
- *Food, Fiber, and Forest Products:* Through its impacts on agriculture, forestry and fisheries, climate change adversely affects food availability, access, and quality, and increases the number of people at risk of hunger, malnutrition, and food insecurity.
- *Urban Areas:* Extreme temperatures, extreme precipitation events, and rising sea levels are increasing risks to urban communities, their health, wellbeing, and livelihood, with the economically and socially marginalized being most vulnerable to these impacts.
- *Rural Areas:* A high dependence on natural resources, weather-dependent livelihood activities, lower opportunities for economic diversity, and limited infrastructural resources subject rural communities to unique vulnerabilities to climate change impacts.
- *Human Health:* Climate change can affect human health, directly through mortality and morbidity caused by heatwaves, floods and other extreme weather events, changes in vector-borne diseases, changes in water and food-borne diseases, and impacts on air quality as well as through indirect pathways such as increased malnutrition and mental health impacts on communities facing climate-induced migration and displacement.
- *Human Security:* Climate change threatens various dimensions of human security, including livelihood security, food security, water security, cultural identity, and physical safety from conflict, displacement, and violence. These impacts are interconnected and unevenly distributed across regions and within societies based on differential exposure and vulnerability.
- *Stratospheric Ozone:* There is strong evidence that anthropogenic influences, particularly the addition of GHGs and ozone-depleting substances to the atmosphere, have led to a detectable reduction in stratospheric ozone concentrations and contributed to tropospheric warming and related cooling in the lower stratosphere. These changes in stratospheric ozone have further influenced the climate by affecting the atmosphere's temperature structure and circulation patterns.
- *Compound events:* Compound events consist of combinations of multiple hazards that contribute to amplified societal and environmental impacts. Observations and projections show that climate change may increase the underlying probability of compound events occurring. To the extent the action alternatives would decrease the rate of CO_2 emissions relative to the relevant No-Action Alternative, they would contribute to the general decreased risk of extreme compound events. While this rulemaking alone would not necessarily decrease compound event frequency and severity from climate change, it would be one of many global actions that, together, could reduce these effects.
- *Tipping Points and Abrupt Climate Change:* Tipping points represent thresholds within Earth systems that could be triggered by continued increases in the atmospheric concentration of GHGs, incremental increases in temperature, or other relatively small or gradual changes related to climate change. For example, the melting of the Greenland ice sheet, Arctic sea-ice loss, destabilization of the West Antarctic ice sheet, and deforestation in the Amazon and dieback of boreal forests are seen as potential tipping points that can cause large-scale, abrupt changes in the climate system and lead to significant impacts on human and natural systems. We note that all of these adverse effects would be mitigated to some degree by our standards.

(d) Qualitative Impacts Assessment

In cases where quantitative impacts assessment is not possible, NHTSA presents the findings of a literature review of scientific studies in the Final EIS, such as in Chapter 6, where NHTSA provides a literature synthesis focusing on existing credible scientific information to evaluate the most significant lifecycle environmental impacts from some of the technologies that may be used to comply with the alternatives. In Chapter 6, NHTSA describes the life-cycle environmental implications related to the vehicle cycle phase considering the materials and technologies (*e.g.,* batteries) that NHTSA forecasts vehicle manufacturers might use to comply with the CAFE and HDPUV FE standards. In Chapter 7, NHTSA discusses EJ and qualitatively describes potential disproportionate impacts on low-income and minority populations. In Chapter 8, NHTSA qualitatively describes potential impacts on historic and cultural resources. In these chapters, NHTSA concludes that impacts would vary between the action alternatives.

2. Conclusion

Based on the foregoing, NHTSA concludes from the Final EIS that Alternative PC6LT8 is the overall environmentally preferable alternative for model years 2027–2031 CAFE standards and Alternative HDPUV14 is the overall environmentally preferable alternative for model years 2030–2035 HDPUV FE standards because, assuming full compliance were achieved regardless of NHTSA's assessment of the costs to industry and society, it would result in the largest reductions in fuel use and CO_2 emissions among the alternatives considered. In addition, Alternative PC6LT8 and Alternative HDPUV14 would result in lower overall emissions levels over the long term of criteria air pollutants and of the toxic air pollutants studied by NHTSA. Impacts on other resources would be proportional to the impacts on fuel use and emissions, as further described in the Final EIS, with Alternative PC6LT8 and Alternative HDPUV14 being expected to have the fewest negative environmental impacts. Although the CEQ regulations require NHTSA to identify the environmentally preferable alternative, NHTSA need not adopt it, as described above. The following section explains how NHTSA balanced the relevant factors to determine which alternative represented the maximum feasible standards, including why NHTSA does not believe that the environmentally preferable alternative is maximum feasible.

NHTSA is informed by the discussion above and the Final EIS in arriving at its conclusion that Alternative PC2LT002 and HDPUV108 is maximum feasible, as discussed below. The following section (Section VI.D) explains how NHTSA balanced the relevant factors to determine which alternatives represented the maximum feasible standards for passenger cars, light trucks, and HDPUVs.

D. Evaluating the EPCA/EISA Factors and Other Considerations To Arrive at the Final Standards

Accounting for all of the information presented in this preamble, in the TSD, in the FRIA, and in the EIS, consistent with our statutory authorities, NHTSA continues to approach the decision of what standards would be ''maximum feasible'' as a balancing of relevant factors and information, both for passenger cars and light trucks, and for

HDPUVs. The different regulatory alternatives considered in this final rule represent different balancing of the factors—for example, PC2LT002, the preferred alternative, would represent a balancing in which NHTSA determined that economic practicability significantly outweighed the need of the U.S. to conserve energy for purposes of the rulemaking time frame. By contrast, PC6LT8, a more stringent alternative, would represent a balancing in which NHTSA determined that the need of the U.S. to conserve energy significantly outweighed economic practicability during the same period. Because the statutory factors that NHTSA must consider are slightly different between passenger cars and light trucks on the one hand, and HDPUVs on the other, the following sections separate the segments and describe NHTSA's balancing approach for each final rule.

1. Passenger Cars and Light Trucks

NHTSA's purpose in setting CAFE standards is to conserve energy, as directed by EPCA/EISA. Energy conservation provides many benefits to the American public, including better protection for consumers against changes in fuel prices, significant fuel savings and reduced impacts from harmful pollution. NHTSA continues to believe that fuel economy standards can function as an important insurance policy against oil price volatility, particularly to protect consumers even as the U.S. has improved its energy independence over time. The U.S. participates in the global market for oil and petroleum fuels. As a market participant—on both the demand and supply sides—the nation is exposed to fluctuations in that market. The fact that the U.S. may produce more petroleum in a given period does not in and of itself protect the nation from the consequences of these fluctuations. Accordingly, the nation must conserve petroleum and reduce the oil intensity of the economy to insulate itself from the effects of market volatility. The primary mechanism for doing so in the transportation sector is to continue to improve fleet fuel economy. In addition, better fuel economy saves consumers money at the gas pump. For example, our analysis estimates that the preferred alternative would reduce fuel consumption by 64 billion gallons through calendar year 2050 and save buyers of new model year 2031 vehicles an average of $639 in gasoline over the lifetime of the vehicle. Moreover, as climate change progresses, the U.S. may face new energy-related security risks if climate effects exacerbate geopolitical tensions and destabilization. Thus, mitigating climate effects by increasing fuel economy standards, as all of the action alternatives in this final rule would do over time, can also potentially improve energy security.

Maximum feasible CAFE standards look to balance the need of the U.S. to conserve energy with the technological feasibility and economic impacts of potential future standards, while also considering other motor vehicle standards of the Government that may affect automakers' ability to meet CAFE standards. To comply with our statutory constraints, NHTSA disallows the application of BEVs (and other dedicated AFVs) in our analysis in response to potential new CAFE standards, and PHEVs are applied only with their charge-sustaining mode fuel economy.

In considering this final rule, NHTSA is mindful of the fact that the standards for model years 2024–2026 included year-by-year improvements compared to the standards established in 2020 that were faster than had been typical since the inception of the CAFE program in the late 1970s and early 1980s. Those standards were intended to correct for the lack of adequate consideration of the need for energy conservation in the 2020 rule and were intended to reestablish the appropriate level of consideration of these effects that had been included in the initial 2012 rule. Thus, though the standards increased significantly when compared to the 2020 rule, they were comparable to the standards that were initially projected as augural standards for the model years included in the 2012 final rule. The world has changed considerably in some ways, but less so in others. Since May 2022, the U.S. economy continues to have strengths and weaknesses; the auto industry remains in the middle of a major transition for a variety of reasons besides the CAFE program. NHTSA is prohibited from considering the fuel economy effects of this transition, but industry commenters argue that NHTSA must not fail to account for the financial effects of this transition. Upon considering the comments, NHTSA agrees that diverting manufacturer resources to paying CAFE non-compliance penalties, as our statutorily-constrained analysis shows manufacturers doing under the more stringent regulatory alternatives, would not aid manufacturers in the transition and would not ultimately improve energy conservation, since non-compliance means that manufacturers are choosing to pay penalties rather than to save fuel. Further stringency increases at a comparable rate, immediately on the heels of the increases for model years 2024–2026, may therefore be beyond maximum feasible for model years 2027–2032.

In the NPRM, NHTSA tentatively concluded that Alternative PC2LT4 was the maximum feasible alternative that best balanced all relevant factors for passenger cars and light trucks built in model years 2027–2032. NHTSA explained that energy conservation was still our paramount objective, for the consumer benefits, energy security benefits, and environmental benefits that it provides. NHTSA expressed its belief that a large percentage of the fleet would remain propelled by ICEs through 2032, despite the potential significant transformation being driven by reasons other than the CAFE standards and stated that the proposal would encourage those ICE vehicles produced during the standard-setting time frame to achieve and maintain significant fuel economies, improve energy security, and reduce GHG emissions and other air pollutants. At the same time, NHTSA stated that our estimates suggest that the proposal would continue to reduce petroleum dependence, saving consumers money and fuel over the lifetime of their vehicles, particularly light truck buyers, among other benefits, while being economically practicable for manufacturers to achieve.

NHTSA further explained that although Alternatives PC3LT5 and PC6LT8 would conserve more energy and provide greater fuel savings benefits and carbon dioxide emissions reductions, NHTSA believed that those alternatives may simply not be achievable for many manufacturers in the rulemaking time frame, particularly given NHTSA's statutory restrictions on the technologies we may consider when determining maximum feasible standards. Additionally, NHTSA expressed concern that compliance with those more stringent alternatives would impose significant costs on individual consumers without corresponding fuel savings benefits large enough to, on average, offset those costs. Within that framework, NHTSA's NPRM analysis suggested that the more stringent alternatives could push more technology application than would be economically practicable, given the rate of increase for the model years 2024–2026 standards, given anticipated reference baseline activity on which our standards would be building, and given a realistic consideration of the rate of response that industry is capable of achieving. In contrast to Alternatives PC3LT5 and PC6LT8, NHTSA argued that Alternative PC2LT4 appeared to come at a cost that the market can bear, appeared to be much more achievable, and would still result in consumer net benefits on average. NHTSA also stated that PC2LT4 would achieve large fuel savings benefits and significant reductions in carbon dioxide emissions. NHTSA therefore tentatively concluded Alternative PC2LT4 was a better proposal than PC3LT5 and PC6LT8 given these factors.

Comments on this tentative conclusion varied widely. In general, automotive and oil industry commenters and conservative think tanks argued that the proposal was beyond maximum feasible,[1335] while environmental and some state commenters argued that a more stringent alternative was likely to be maximum feasible.

Some commenters supported the proposed PC2LT4 alternative as maximum feasible.[1336] ICCT stated, for example, that ''Substantial public and private sector investments and a comprehensive package of federal and state level policies make the timing and stringency of the proposed rule achievable, feasible, and cost-effective. ICCT recommends its finalization as quickly as possible. Doing so will provide a clear long-term signal that automakers, suppliers, and other stakeholders need to make needed investments with confidence.'' [1337] MEMA agreed with the proposal that light truck stringency could be advanced faster than passenger car stringency, stating that ''The current passenger car and light truck markets have different levels of advanced technology penetration and differ in terms of the extent of technological improvements that can be made.'' [1338]

Other commenters argued that more stringent standards were likely to be maximum feasible. Many stakeholders commented that standards should be at least as high as PC2LT4.[1339] ACEEE argued that more stringent standards than PC2LT4 are feasible because automakers have stated that they will build more BEVs and the IRA tax credits will spur more BEVs, and if automakers build more BEVs than NHTSA projects, NHTSA's standards would be ineffective.[1340] NESCAUM and OCT commented that more stringent standards are economically practicable, technologically feasible, and would keep better pace with standards from EPA and California.[1341]

A number of commenters relatedly argued that NHTSA should prioritize energy conservation and weigh the need of the U.S. to conserve energy more heavily, and find that more stringent standards than the proposal were maximum feasible.[1342] Commenters focused on issues such as the urgency of climate crisis, its unequal impacts, the need to meet the U.S.'s Paris Accord targets, public health effects, environmental justice, and consumer fuel costs (where more stringent standards ''make a meaningful difference to low-income households and households of color that generally spend a greater proportion of their income on transportation costs'').[1343] Some state commenters, like Wisconsin DNR, urged NHTSA to set the most stringent standards due to concerns about criteria and GHG emissions, and stated that Wisconsin plans to support these efforts through electrification planning and infrastructure investments.[1344]

Some commenters stated that light truck stringency should increase faster than passenger car stringency, arguing that the current design of the standards encourages companies to build trucks instead of cars, with resulting worse outcomes for both fuel savings and safety, due to the proliferation of larger vehicles on the roads.[1345] The States and Cities commenters argued that NHTSA is allowed to set standards that increase faster for light trucks than for passenger cars, and that therefore NHTSA should consider PC3LT5 or PC2.5LT7, depending on what the record indicated would be maximum feasible.[1346] These commenters stated that although net benefits for passenger cars may be negative, net benefits for light trucks were positive, with a peak at the most stringent alternative, and therefore NHTSA should pick PC3LT5,[1347] and that either PC3LT5 or PC2.5LT7 ''are technologically feasible, economically practicable, and effectuate the purpose of EPCA to conserve energy, thus satisfying the 'maximum feasible' mandate.'' [1348] These commenters further argued that NHTSA should not rely on an ''uncertain'' concern about consumer demand to such an extent that it ignored the ''overarching goal of fuel conservation,'' 793 F.2d 1322, 1340 (D.C. Cir. 1986), and noted that the estimated per-vehicle costs for PC3LT5 were actually lower than what NHTSA had described as economically practicable for the model years 2024–2026 standards.[1349] These commenters stated that NHTSA must not give so much weight to economic practicability as to reject PC3LT5, because NHTSA is afraid of possibly burdening sales through extra cost.

SELC also supported NHTSA choosing PC3LT5, arguing that its societal benefits were higher than the proposal, and that choosing a more stringent alternative than the proposal would provide a buffer against uncertainty in the value of the SC–GHG and against the risk that compliance flexibilities could end up undermining fuel savings.[1350]

A number of other commenters stated that NHTSA should choose PC6LT8, because that alternative would result in the largest fuel savings and climate benefits,[1351] and would be most beneficial for public health.[1352] NHTSA

[1335] For example, Subaru, Docket No. NHTSA–2023–0022–58655, at 3; Heritage Foundation, Docket No. NHTSA–2023–0022–61952, at 2; American Consumer Institute, Docket No. NHTSA–2023–0022–50765, at 1; BMW, Docket No. NHTSA–2023–0022–58614, at 2.

[1336] For example, Arconic, Docket No. NHTSA–2023–0022–48374, at 3; DC Government Agencies, Docket No. NHTSA–2023–0022–27703, at 1.

[1337] ICCT, Docket No. NHTSA–2023–0022–54064, at 3, 4.

[1338] MEMA, Docket No. NHTSA–2023–0022–59204–A1, at 2–3.

[1339] Individual citizen form letters, Docket No. NHTSA–2023–0022–63051; MPCA, Docket No. NHTSA–2023–0022–60666, at 1; ELPC, Docket No. NHTSA–2023–0022–60687, at 3.

[1340] ACEEE, Docket No. NHTSA–2023–0022–60684, at 2.

[1341] NESCAUM, Docket No. NHTSA–2023–0022–57714, at 2; OCT, Docket No. NHTSA–2023–0022–51242, at 3.

[1342] *See, e.g.,* EDF, Docket No. NHTSA–2023–0022–62360, at 1–2; Tesla, Docket No. NHTSA–2023–0022–60093, at 10; IEC, Docket No. NHTSA–2023–0022–24513, at 1.

[1343] SELC, Docket No. NHTSA–2023–0022–60224, at 4, 6; IEC, Docket No. NHTSA–2023–0022–24513, at 1; Chispa LCV, Docket No. NHTSA–2023–0022–24464, at 1; LCV, Docket No. NHTSA–2023–0022–27796, at 1.

[1344] Wisconsin DNR, Docket No. NHTSA–2023–0022–21431, at 2.

[1345] SELC, Docket No. NHTSA–2023–0022–60224, at 6; Public Citizen, Docket No. NHTSA–2023–0022–57095, at 2.

[1346] States and Cities, Docket No. NHTSA–2023–0022–61904, Attachment 2, at 2.

[1347] States and Cities, Docket No. NHTSA–2023–0022–61904, Attachment 2, at 32.

[1348] States and Cities, Docket No. NHTSA–2023–0022–61904, Attachment 2, at 43.

[1349] States and Cities, Docket No. NHTSA–2023–0022–61904, Attachment 2, at 31.

[1350] SELC, Docket No. NHTSA–2023–0022–60224, at 7.

[1351] Lucid, Docket No. NHTSA–2023–0022–50594, at 5; Colorado State Agencies, Docket No. NHTSA–2023–0022–57625, at 2; Green Latinos, Docket No. NHTSA–2023–0022–59638, at 1; BICEP Network, Docket No. NHTSA–2023–0022–61135, at 1; Blue Green Alliance, Docket No. NHTSA–2023–0022–61668, at 1; Minnesota Rabbinical Association, Docket No. NHTSA–2023–0022–28117, at 1; ZETA, Docket No. NHTSA–2023–0022–60508, at 18; CALSTART, Docket No. NHTSA–2023–0022–61099, at 1.

[1352] Public Citizen, Docket No. NHTSA–2023–0022–57095, at 1; Colorado State Agencies, Docket No. NHTSA–2023–0022–57625, at 2; Green Latinos, Docket No. NHTSA–2023–0022–59638, at 1; ZETA, Docket No. NHTSA–2023–0022–60508, at 18; CALSTART, Docket No. NHTSA–2023–0022–

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received over 70,000 form letters and comments from individuals in favor of NHTSA choosing PC6LT8.[1353] Public Citizen commented that PC6LT8 is technologically and economically feasible, because the technology is available and it can be afforded by companies, who are making record profits.[1354] ACEEE similarly argued that PC6LT8 can be met with SHEVs and a variety of ICE-improving technology that will save consumers money at the pump, and concluded that therefore PC6LT8 is maximum feasible.[1355] Several commenters cited a Ceres study finding that the most stringent standards would be best for the competitiveness of the auto industry.[1356] ZETA commented that PC6LT8 is cost-effective and feasible, and best for energy security.[1357]

OCT found even PC6LT8 to be insufficiently stringent, arguing that internal combustion engines should be reduced to zero by 2027 in order to achieve climate targets. In lieu of this, that commenter requested that NHTSA align the CAFE standards with California's target of 100% ZEV for the light-duty fleet by 2035.[1358]

In contrast, many other commenters expressed concern that the proposed standards were too stringent, and many commenters encouraged NHTSA to balance the factors differently for the final rule and find that less stringent standards were maximum feasible. Some commenters encouraged NHTSA to weigh technological feasibility and economic practicability more heavily.[1359] For example, the Alliance argued that ''When the majority of manufacturers and a significant portion of the fleet (or worse yet the fleet on average) are projected to be unable to meet (a question of technological feasibility) or unwilling to meet (a question of economic practicability) the proposed standards, the proposal clearly exceeds maximum feasibility for both passenger cars and light trucks.'' [1360] The American Consumer Institute stated that economic practicability and consumer choice were more important than environmental concerns, and argued that EPCA focuses on direct consumer benefits rather than environmental benefits.[1361] The Alliance stated that the proposed standards were too stringent because the average per-vehicle price increase was estimated to be $3,000, which ''ignored'' economic practicability.[1362]

Many of these commenters also mentioned compliance shortfalls and estimated penalties associated with the proposed standards. Volkswagen argued that it was arbitrary and capricious to set standards that result in nearly everyone being out of compliance.[1363] Toyota stated that the estimated $14 billion in penalties demonstrates ''that the technology being relied upon is insufficient to achieve the proposed standards,'' [1364] and Volkswagen and Jaguar commented that effectively mandating penalties diverts resources for no environmental or energy benefit.[1365] POET commented that ''The D.C. Circuit has found that 'a standard with harsh economic consequences for the auto industry . . . would represent an unreasonable balancing of EPCA's policies,''' and has previously approved NHTSA stating that ''If manufacturers had to restrict the availability of large trucks and engines in order to adhere to CAFE standards, the effects . . . would go beyond the realm of 'economic practicability' as contemplated in the Act.'' [1366] Toyota further argued that while NHTSA had stated in the NPRM that automakers could manufacture more BEVs rather than pay penalties, ''The preferred alternative standards do not account for the cost of a manufacturer to pursue higher levels of electrification than currently in the baseline assumption. Further, the expectation that manufacturers can simply make and sell more EVs ignores the abrupt jump in 2027 model year stringency,'' due to FCIV and PEF changes, as well as the uncertainty of the market.[1367] Jaguar also commented that the stringency of the early years of the proposed standards was particularly problematic.[1368]

The Heritage Foundation commented that ''In administering the fuel economy program, NHTSA must (i) respect the practical needs and desires of American car buyers; (ii) take into account the economic realities of supply and demand in the auto markets; (iii) protect the affordability of vehicle options for American families; (iv) preserve the vitality of the domestic auto industry, which sustains millions of good-paying American jobs; (v) maintain highway traffic safety for the country; (vi) consider the nation's need to conserve energy; and (vii) advance the goal of reducing America's dependence on foreign supplies of critical inputs.'' [1369] The America First Policy Institute commented that fuel economy standards do not save consumers enough money, and that a better way to help consumers save money on fuel is ''creating a regulatory environment that is more amenable to oil production and refining.'' [1370] CEA commented that fuel efficiency standards are a bad way to reduce carbon from the transport sector, because the compliance cost per ton is much larger than the SC–GHG you used.[1371]

Some comments focused on the feasibility of the proposed passenger car standards. For example, Volkswagen pointed to an analysis from the Alliance stating that most of the industry would be unable to comply with the passenger car standards in model years 2027–2031.[1372] The West Virginia Attorney General's Office argued that NHTSA ''even admits that massive EV increases are necessary to comply with the

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61099, at 1; Mothers & Others for Clean Air, Docket No. NHTSA–2023–0022–60614, at 1.

[1353] NRDC form letter, Docket No. NHTSA–2023–0022–57375; Consumer Reports, Docket No. NHTSA–2023–0022–61098, Attachment 3; Climate Hawks, Docket No. NHTSA–2023–0022–61094, at 1.

[1354] Public Citizen, Docket No. NHTSA–2023–0022–57095, at 2.

[1355] ACEEE, Docket No. NHTSA–2023–0022–60684, at 3.

[1356] Ceres, Docket No. NHTSA–2023–0022–28667, at 1; Conservation Voters of South Carolina, Docket No. NHTSA–2023–0022–27800, at 1; Minnesota Rabbinical Association, Docket No. NHTSA–2023–0022–28117, at 1; CALSTART, Docket No. NHTSA–2023–0022–61099, at 1.

[1357] ZETA, Docket No. NHTSA–2023–0022–60508, at 1.

[1358] OCT, Docket No. NHTSA–2023–0022–51242, at 2–4.

[1359] The Alliance, Docket No. NHTSA–2023–0022–60652, Attachment 2, at 2; Nissan, Docket No. NHTSA–2023–0022–60696, at 10; U.S. Chamber of Commerce, Docket No. NHTSA–2023–0022–61069, at 6.

[1360] The Alliance, Docket No. NHTSA–2023–0022–60652, Attachment 2, at 6–7.

[1361] American Consumer Institute, Docket No. NHTSA–2023–0022–50765, at 2; NADA, Docket No. NHTSA–2023–0022–58200, at 5.

[1362] The Alliance, Docket No. NHTSA–2023–0022–60652, Attachment 2, at 2.

[1363] Volkswagen, Docket No. NHTSA–2023–0022–58702, at 5.

[1364] Toyota, Docket No. NHTSA–2023–0022–61131, at 2.

[1365] Volkswagen, Docket No. NHTSA–2023–0022–58702, at 5; Jaguar, Docket No. NHTSA–2023–0022–57296, at 4.

[1366] POET, Docket No. NHTSA–2023–0022–61561, at 16, citing *Center for Auto Safety* v. *NHTSA,* 793 F.2d 1322 (D.C. Cir. 1986).

[1367] Toyota, Docket No. NHTSA–2023–0022–61131, at 20.

[1368] Jaguar, Docket No. NHTSA–2023–0022–57296, at 4.

[1369] Heritage Foundation, Docket No. NHTSA–2023–0022–61952, at 4.

[1370] America First Policy Institute, Docket No. NHTSA–2023–0022–61447, at 4.

[1371] CEA, Docket No. NHTSA–2023–0022–61918, at 12. NHTSA notes that the purpose of the CAFE standards is energy conservation and reduction of fuel consumption, and that reducing CO_2 emissions is a co-benefit of the standards. While NHTSA accounts for the economic benefit of reducing CO_2 emissions in our cost-benefit analysis, NHTSA's decision regarding maximum feasible stringency is merely informed by and not driven by the cost-benefit analysis, and therefore NHTSA disagrees that cost per ton would be a relevant metric for distinguishing regulatory alternatives.

[1372] Volkswagen, Docket No. NHTSA–2023–0022–58702, at 3.

Proposed Rule—after all, 'manufacturers will find it difficult to improve fuel economy with [internal combustion] engine technologies.' (citing NPRM at 88 FR at 56259)'' [1373] CEA commented that NHTSA had not independently justified the passenger car standards and was attempting to downplay their difficulty by bundling the results with those for the light truck standards.[1374] Several commenters noted that net benefits for the passenger car alternatives were negative,[1375] with Valero arguing that NHTSA was attempting to bypass the negative net benefits by asserting that the costs to consumers are outweighed by the environmental benefits, which Valero stated were very minor and which would disappear if NHTSA had conducted a full life-cycle analysis of BEV production.[1376] POET argued that net benefits should be positive for passenger car drivers,[1377] and a number of commenters requested that the passenger car standards be set at the No-Action level for the final rule because of net benefits (both societal and to consumers).[1378] Porsche further argued that ''In this specific proposal, where costs so dramatically outweigh consumer private benefits, it would appear NHTSA is not balancing economic practicability, but rather may be inappropriately minimizing it.'' [1379]

Other comments focused on the feasibility of the proposed light truck standards. Volkswagen argued that manufacturers will have to decrease utility to meet the proposed light truck standards.[1380] Porsche expressed concern that raising light truck stringency faster than passenger car stringency was unfair and ''creates inequity among products, and ultimately among OEMs who sell different types of vehicles.'' [1381] Stellantis similarly argued that ''Under an appropriate rule, multiple manufacturers should be able to readily meet standards in a category as large as the light truck/SUV category, so as to maintain competition and consumer choice and avoid unduly benefiting a single manufacturer. A rule where only one manufacturer can comfortably comply is arbitrary and capricious, at least a 'relevant factor' that NHTSA has failed to consider.'' [1382]

The Alliance provided extensive comments as to why the stringency of light truck standards should not increase faster than the stringency of passenger car standards. First, they stated that light trucks are bigger and heavier with generally larger frontal area (decreasing their fuel economy), and they can perform work like off-roading, towing and hauling, which also decrease their fuel economy.[1383] Second, they commented that S&P Global Mobility data shows that from model year 2012 to model year 2022, setting aside alternative fuel vehicles, passenger car fuel consumption improved 12 percent, while light truck fuel consumption improved 18 percent.[1384] And third, they disagreed at length that light trucks had less fuel economy-improving technology than passenger cars, stating that

- The powertrain efficiency of the car and truck fleets, excluding EVs, are the same—24 percent.[1385]
- Light trucks have also generally decreased roadload more quickly than passenger cars over the last decade, and the passenger car fleet (and cars as a subfleet) increased roadload.[1386] Passenger cars have more aero and MR in the reference baseline, but light trucks have more low rolling resistance technology, and light trucks are limited in their ability to apply aero technologies because of pickup trucks.[1387]
- Light trucks have greater electrification tech levels (12v start-stop, SHEV) than passenger cars, which have a higher proportion of BEVs, which NHTSA is prohibited from considering anyway, so light trucks are more electrified for NHTSA's purposes than passenger cars, and these trends are projected to continue.[1388] (Ford similarly argued that LT4 was too stringent because NHTSA did not account for the ''likely [slower] rates of [full] electrification in the Truck segments as compared to Car segments,'' nor for the transfer cap—in EPA's program, manufacturers can just overcomply with passenger car standards and transfer as many credits as needed to offset light truck shortfalls, but NHTSA's program doesn't allow this, so LT4 is beyond maximum feasible.[1389])
- ''While NHTSA projects that light trucks have a somewhat higher usage of basic ICE technologies than passenger cars, manufacturers may be using engine stop-start systems in combination with basic engine technologies to achieve similar benefits as passenger cars see with low-level ICE technologies. Light trucks make higher use of mid-level ICE technologies than passenger cars, and both fleets exhibit similar use of high-level ICE technologies. Based on these trends, it appears that baseline ICE technology penetration is similar or higher for light trucks as compared to passenger cars.'' [1390]
- ''Transmission technology in the non-strongly electrified fleet is similar for both passenger cars and light trucks.'' [1391]

Based on all of these points, the Alliance concluded that light trucks have similar or more technology than passenger cars, and argued that it was unfair of NHTSA to assert that light trucks have more room to improve and should increase in stringency faster.[1392] Several commenters argued that NHTSA should finalize PC2/LT2, because such an alternative would be more fair to manufacturers of trucks who would otherwise have to work harder than manufacturers who build more cars, and because ''If NHTSA applies the same 2% rate of increase to both car and truck fleets, that 2% increase in mpg on vehicles included in the truck fleet will

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[1373] West Virginia Attorney General's Office, Docket No. NHTSA–2023–0022–63056, at 6, 12. NHTSA notes that this comment incompletely quotes the agency's discussion in the NPRM, in which NHTSA explained on the same page that it was not proposing to set passenger car standards higher than 2 percent per year *because* NHTSA is prohibited from considering the fuel economy of BEVs or the full fuel economy of PHEVs, and so NHTSA realized that expecting manufacturers to achieve more stringent standards with ICEVs and maintain reasonable costs was unrealistic.

[1374] CEA, NHTSA–2023–0022–61918, at 25–26.

[1375] For example, KCGA, Docket No. NHTSA–2023–0022–59007, at 4.

[1376] Valero, Docket No. NHTSA–2023–0022–58547, Attachment A, at 14.

[1377] POET, Docket No. NHTSA–2023–0022–61561, at 12.

[1378] MCGA, Docket No. NHTSA–2023–0022–60208, at 14–15; Porsche, Docket No. NHTSA–2023–0022–59240, at 3; AmFree, Docket No. NHTSA–2023–0022–62353, at 5; RFA *et al.* 2, Docket No. NHTSA–2023–0022–57625, at 14.

[1379] Porsche, Docket No. NHTSA–2023–0022–59240, at 3.

[1380] Volkswagen, Docket No. NHTSA–2023–0022–58702, at 2.

[1381] Stellantis, Docket No. NHTSA–2023–0022–61107, at 3; AAPC, Docket No. NHTSA–2023–0022–60610, at 1.

[1382] POET, Docket No. NHTSA–2023–0022–61561, at 12.

[1383] The Alliance, Docket No. NHTSA–2023–0022–60652, Appendix C, at 24; U.S. Chamber of Commerce, Docket No. NHTSA–2023–0022–61069, at 2.

[1384] The Alliance, Docket No. NHTSA–2023–0022–60652, Appendix C, at 24–25.

[1385] The Alliance, Docket No. NHTSA–2023–0022–60652, Appendix C, at 26.

[1386] The Alliance, Docket No. NHTSA–2023–0022–60652, Appendix C, at 26.

[1387] The Alliance, Docket No. NHTSA–2023–0022–60652, Appendix C, at 32.

[1388] The Alliance, Docket No. NHTSA–2023–0022–60652, Appendix C, at 27.

[1389] Ford, Docket No. NHTSA–2023–0022–60837, at 7.

[1390] The Alliance, Docket No. NHTSA–2023–0022–60652, Appendix C, at 29–30.

[1391] The Alliance, Docket No. NHTSA–2023–0022–60652, Appendix C, at 31.

[1392] The Alliance, Docket No. NHTSA–2023–0022–60652, Appendix C, at 33; Volkswagen, Docket No. NHTSA–2023–0022–58702, at 3.

save significantly more gallons per year than the car fleet.'' [1393]

Several commenters discussed the interaction of NHTSA's proposal with EPA's proposal and other government statements and programs. The Alliance commented that CAFE standards should be expressly offset from EPA's GHG standards ''considering the agencies' differences in the treatment of EVs and compliance flexibilities.'' [1394] AVE and Nissan stated that NHTSA must align with EPA's rule.[1395] The U.S. Chamber of Commerce stated that all agencies should work together to ensure manufacturers can build a single fleet of compliant vehicles with sufficient lead time and regulatory certainty.[1396] Toyota argued that the CAA is a better tool to ''support the shift to electrification,'' and instead NHTSA should ''focus on economically practicable ICE improvements considering the resources being diverted to electrification.'' [1397] Volkswagen commented that NHTSA should ''make the CAFE target and framework consistent with'' E.O. 14037.[1398] Jaguar commented that the proposal was too stringent, and that NHTSA should follow the ''U.S. Blueprint for Transportation Decarbonization'' published in early 2023, which built on E.O. 14037 and called for 50 percent of all new passenger cars and light trucks in model year 2030 to be zero-emission vehicles, including BEVs, PHEVs, and FCEVs.[1399] In contrast, the West Virginia Attorney General's Office and the Motorcycle Riders Foundation commented that CAFE rules are part of a coordinated Biden Administration strategy to force a full transition to BEVs.[1400]

A number of commenters continued with the theme of CAFE standards somehow forcing a full transition to BEVs. NAM and the Motorcycle Riders Foundation commented that NHTSA was forcing manufacturers to build only BEVs, that consumers should have choices, like strong hybrids and PHEVs, and that the market should decide whether and when BEVs should be introduced.[1401] MOFB expressed concern that NHTSA was forcing farmers to purchase BEVs, and argued that BEVs would not work well for farmers due to insufficient rural charging infrastructure and the time necessary for recharging, lack of range, inability to haul loads or perform in extreme temperatures, and a lack of available service technicians.[1402] CEI, BMW, Jaguar, and Nissan commented that the proposal would force manufacturers both to build more BEVs and to improve their ICEVs,[1403] and Jaguar stated that manufacturers may have to stop offering certain of their vehicles in order to comply.[1404] Volkswagen, Jaguar, Kia, and Hyundai commented that requiring improvements in ICEVs hindered their efforts to transition to full electrification.[1405] In contrast, POET stated that the proposal was forcing manufacturers to build BEVs and *restricting* their ability to build ICEVs, and argued that this effort was contrary to *West Virginia* v. *EPA* which says agencies cannot ''substantially restructure the American energy market'' in a way that ''Congress had conspicuously and repeatedly declined to enact itself.'' [1406] API stated that NHTSA does not have authority to impose standards that effectively require a portion of the fleet to be BEV.[1407] KCGA argued that BEVs are heavier than ICE vehicles and thus worse for safety,[1408] while the Missouri Corn Growers Association argued that the proposal would significantly hurt working farmers because in combination with EPA's proposal, it ''may cost the U.S. corn industry nearly one-billion bushels annually in lost corn demand,'' and it would force farmers to buy BEVs when they need ICEVs.[1409] Several commenters stated that forcing a full transition to BEVs would be more expensive and less effective than requiring ICE improvements or high-octane low-carbon fuels.[1410]

Commenters also focused on the effect that they believed NHTSA's inclusion of BEVs in the analysis (generally, in the regulatory reference baseline) had on NHTSA's decision to propose PC2LT4. Valero commented that ''The more EVs are assumed to penetrate the market in the baseline scenario, the easier it is for vehicle manufacturers to comply with the [proposed CAFE] standards . . . , because an EV receives the maximum compliance credit possible in the CAFE program. To help justify highly stringent CAFE standards, the agency paints a picture of the baseline where state-level ZEV mandates in sixteen states are implemented without difficulty and lead to a dramatic increase in EV sales from 2022 to 2032.'' [1411] Several commenters asserted that the proposed standards would not be feasible if BEVs were excluded from the analysis,[1412] while other commenters expressed concern that building the number of BEVs assumed in NHTSA's analysis would be more difficult than NHTSA acknowledged, due to uncertainty in future battery prices, charging infrastructure, available manufacturer capital resources, and so on.[1413] Toyota commented that while NHTSA claimed that BEVs in the reference baseline would happen regardless of new CAFE standards, NHTSA then went on to assume that strong hybrids would replace ICEs, when those ICEs existed because of the BEVs in the reference baseline.[1414] The Alliance commented

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[1393] AAPC, Docket No. NHTSA–2023–0022–60610, at 1; Ford, Docket No. NHTSA–2023–0022–60837, at 4; Missouri Farm Bureau, Docket No. NHTSA–2023–0022–61601, at 2.

[1394] The Alliance, Docket No. NHTSA–2023–0022–27803, at 2.

[1395] AVE, Docket No. NHTSA–2023–0022–60213, at 2; Nissan, Docket No. NHTSA–2023–0022–60696, at 10.

[1396] U.S. Chamber of Commerce, Docket No. NHTSA–2023–0022–61069, at 6.

[1397] Toyota, Docket No. NHTSA–2023–0022–61131, at 2.

[1398] Volkswagen, Docket No. NHTSA–2023–0022–58702, at 2.

[1399] Jaguar, Docket No. NHTSA–2023–0022–57296, at 2, 3.

[1400] West Virginia Attorney General's Office, Docket No. NHTSA–2023–0022–63056, at 6; Motorcycle Riders Foundation, Docket No. NHTSA–2023–0022–63054, at 1.

[1401] NAM, Docket No. NHTSA–2023–0022–59203–A1, at 1; Motorcycle Riders Foundation, Docket No. NHTSA–2023–0022–63054, at 1.

[1402] Missouri Farm Bureau, Docket No. NHTSA–2023–0022–61601, at 2.

[1403] CEI, Docket No. NHTSA–2023–0022–61121, at 6; BMW, Docket No. NHTSA–2023–0022–58614, at 2; Jaguar, Docket No. NHTSA–2023–0022–57296, at 4; Nissan, Docket No. NHTSA–2023–0022–60696, at 10.

[1404] Jaguar, Docket No. NHTSA–2023–0022–57296, at 4.

[1405] Volkswagen, Docket No. NHTSA–2023–0022–58702, at 3; Jaguar, Docket No. NHTSA–2023–0022–58702, at 4; Kia, Docket No. NHTSA–2023–0022–58542–A1, at 2; Hyundai, Docket No. NHTSA–2023–0022–48991, at 1.

[1406] POET, Docket No. NHTSA–2023–0022–61561, at 16–17.

[1407] API, Docket No. NHTSA–2023–0022–60234, at 4.

[1408] KCGA, Docket No. NHTSA–2023–0022–59007, at 3.

[1409] Missouri Corn Growers Association, Docket No. NHTSA–2023–0022–58413, at 1.

[1410] KCGA, Docket No. NHTSA–2023–0022–59007, at 5; POET, Docket No. NHTSA–2023–0022–61561, at 17; RFA *et al.* 2, Docket No. NHTSA–2023–0022–57625, at 2.

[1411] Valero, Docket No. NHTSA–2023–0022–58547, Attachment C, at 1.

[1412] Volkswagen, Docket No. NHTSA–2023–0022–58702, at 3; The Alliance, Docket No. NHTSA–2023–0022–60652, Attachment 2, at 2; Nissan, Docket No. NHTSA–2023–0022–60696, at 6; SEMA, Docket No. NHTSA–2023–0022–57386, at 3–4; Toyota, Docket No. NHTSA–2023–0022–61131, at 9; U.S. Chamber of Commerce, Docket No. NHTSA–2023–0022–61069, at 2–3.

[1413] Valero, Docket No. NHTSA–2023–0022–58547, Attachment D, at 1, 7; Subaru, Docket No. NHTSA–2023–0022–58655, at 3; KCGA, Docket No. NHTSA–2023–0022–59007, at 3; NAM, Docket No. NHTSA–2023–0022–59203–A1, at 1; AFPM, Docket No. NHTSA–2023–0022–61911, Attachment 2, at 36. NHTSA notes that it always has authority to amend CAFE standards based on new information and as appropriate, as long as statutory lead time requirements are met.

[1414] Toyota, Docket No. NHTSA–2023–0022–61131, at 9.

that when it ran the model taking BEVs out of the reference baseline, setting PHEV electric operation to zero for all years, setting fine payments to zero, and otherwise keeping standard-setting restrictions, ''Over a third of passenger cars are in fleets that do not meet the proposed standard in model years 2027–2032. For light trucks almost a third of production is in fleets that do not meet standards in model year 2027. In model year 2028, over three quarters of vehicles are in fleets that do not meet the proposed standard, and in model year 2029 and later nine out of every ten vehicles are in a fleet that do not meet the proposed standard.'' [1415] CEA argued that even though NHTSA stated in the NPRM that based on the sensitivity analysis, NHTSA would have made the same decision even if state ZEV programs were excluded, NHTSA still acknowledges that less stringent alternatives would have had higher net benefits in that case, and it would be arbitrary and capricious to decide to pick a more stringent alternative for no good reason.[1416] RFA *et al.* 2 argued that NHTSA had based the maximum feasible determination on allowing BEVs starting in model year 2033, which they stated was contrary to 32902(h).[1417]

A number of commenters expressed further concern that DOE's proposed revisions to the PEF, combined with the inclusion of BEVs in NHTSA's reference baseline, made the proposed standards infeasible.[1418] Jaguar commented that the proposed standards were too difficult with the proposed PEF revision ''step change,'' especially for manufacturers who were already at the cap for AC/OC,[1419] and stated that NHTSA must ''stop the step change.'' [1420] Subaru, Stellantis, BMW, and Toyota also commented that the proposed new PEF would make CAFE compliance significantly more difficult, and the proposed standards beyond maximum feasible.[1421] Subaru and Stellantis argued that NHTSA should not have accounted for the proposed PEF revisions in the NPRM analysis.[1422] Volkswagen and AAPC commented that the proposed new PEF raises lead time concerns in terms of how manufacturers would comply with CAFE standards, because manufacturer plans had been based on the then-existing PEF value and revisions would mean that more BEVs (by accelerating capital investments) would be necessary to achieve the same compliance levels or face penalties.[1423] Jaguar added that the proposed new PEF plus the agencies' proposals to remove/reduce AC/OC would make compliance more expensive and imperil the industry's transition to full electrification.[1424] Volkswagen and AAPC also expressed concern that the proposed new PEF would lead to different compliance answers for NHTSA and EPA.[1425] GM stated that if the proposed new PEF is finalized, GM would not support PC2LT4; that if the PEF remained at the then-existing value, GM would support PC2LT4; and that if the proposed new PEF took effect in model year 2030, GM *could* support PC2LT4 but still had concern regarding ''substantial CAFE/GHG alignment issues starting'' whenever the new PEF goes into effect.[1426]

NHTSA has considered these comments carefully, although we note that some of them are beyond our ability to consider—specifically, if NHTSA is prohibited by statute from considering the fuel economy of electric vehicles in determining maximum feasible fuel economy standards, NHTSA does not believe that it can specifically consider the fact that changing the PEF value may change manufacturers' CAFE compliance strategies in future model years. The PEF value is literally the value that turns BEV energy consumption into fuel economy, and BEV fuel economy is exactly what NHTSA may not consider in determining maximum feasible standards (among other things).

However, NHTSA finds some of the comments to be persuasive, particularly regarding the idea that the proposed light truck standards may well be too stringent if manufacturers are going to successfully undertake the technological transition that NHTSA cannot consider directly, and the idea that compliance shortfalls that result in civil penalties and no additional fuel savings benefit neither manufacturers, nor consumers, nor energy conservation.

Comments regarding the stringency of the passenger car fleet were less contentious than those regarding stringency of the light truck fleet. NHTSA agreed with many of the commenters, including the Alliance, that maintaining the proposed stringency levels for the passenger car fleet was acceptable, when considered in conjunction with a less stringent light truck standard. GM, too, stated that it could accept the proposed stringency for passenger cars under certain circumstances.

In response to these comments, for the final rule NHTSA created a new alternative, PC2LT002, combining elements of alternatives presented in the NPRM analysis, out of concern that existing manufacturer commitments to technology development make further improvements to the light truck fleet economically impracticable for model years 2027–2028, due to the need to reserve development and production funds for other purposes, and make light truck improvements at the proposed rate beyond economically practicable for model years 2029–2031.

The following text will walk through the four statutory factors in more detail and discuss NHTSA's decision-making process more thoroughly. The balancing of factors presented here represents NHTSA's thinking based on all of the information presented by the commenters and in the record for this final rule.

For context and the reader's reference, here again are the regulatory alternatives among which NHTSA has chosen maximum feasible CAFE standards for model years 2027–2031, representing different annual rates of stringency increase over the required levels in model year 2026:

[1415] The Alliance, Docket No. NHTSA–2023–0022–60652, Appendix A, at 7–8.

[1416] CEA, Docket No. NHTSA–2023–0022–61918, at 8.

[1417] RFA *et al.* 2, Docket No. NHTSA–2023–0022–57625, at 11.

[1418] Kia, Docket No. NHTSA–2023–0022–58542–A1, at 2; AAPC, Docket No. NHTSA–2023–0022–60610, at 3–5; Honda, Docket No. NHTSA–2023–0022–61033, at 6.

[1419] Jaguar, Docket No. NHTSA–2023–0022–57296, at 4.

[1420] Jaguar, Docket No. NHTSA–2023–0022–57296, at 6.

[1421] Subaru, Docket No. NHTSA–2023–0022–58655, at 3; Stellantis, Docket No. NHTSA–2023–0022–61107, at 3–8; BMW, Docket No. NHTSA–2023–0022–58614, at 2; Toyota, Docket No. NHTSA–2023–0022–61131, at 2, 14.

[1422] Subaru, Docket No. NHTSA–2023–0022–5865, at 4; Stellantis, Docket No. NHTSA–2023–0022–61107, at 4.

[1423] Volkswagen, Docket No. NHTSA–2023–0022–58702, at 3; AAPC, Docket No. NHTSA–2023–0022–60610, at 5.

[1424] Jaguar, Docket No. NHTSA–2023–0022–57296, at 3, 4.

[1425] Volkswagen, Docket No. NHTSA–2023–0022–58702, at 6; AAPC, Docket No. NHTSA–2023–0022–60610, at 3–5.

[1426] GM, Docket No. NHTSA–2023–0022–60686, at 6.

Table VI-23: Regulatory Alternatives Under Consideration for MYs 2027-2031 Passenger Cars and Light Trucks

Name of Alternative	Passenger Car Stringency Increases, Year-Over-Year	Light Truck Stringency Increases, Year-Over-Year
No-Action Alternative	n/a	n/a
Alternative PC2LT002 (Preferred Alternative)	2%	0% (MY 2027-2028) 2% (MY 2029-2031)
Alternative PC1LT3	1%	3%
Alternative PC2LT4	2%	4%
Alternative PC3LT5	3%	5%
Alternative PC6LT8	6%	8%

In evaluating the statutory factors to determine maximum feasible standards, EPCA's overarching purpose of energy conservation suggests that NHTSA should begin with the need of the U.S. to conserve energy. According to the analysis presented in Section V and in the accompanying FRIA, Alternative PC6LT8 is estimated to save consumers the most in fuel costs compared to any of the baselines.[1427] Even in the rulemaking time frame of model years 2027–2032, when many forces other than CAFE standards will foreseeably be driving higher rates of passenger car and light truck electrification, NHTSA believes that gasoline will still likely be the dominant fuel used in LD transportation. This means that consumers, and the economy more broadly, remain subject to fluctuations in gasoline price that impact the cost of travel and, consequently, the demand for mobility. The American economy is largely built around the availability of affordable personal transportation. Vehicles are long-lived assets, and the long-term price uncertainty and volatility of petroleum prices still represents a risk to consumers. By increasing the fuel economy of vehicles in the marketplace, more stringent CAFE standards help to better insulate consumers, and the economy more generally, against these risks over longer periods of time. Fuel economy improvements that reduce demand are an effective hedging strategy against price volatility because gasoline prices are linked to global oil prices. Continuing to reduce the amount of money that consumers spend on vehicle fuel thus remains an important consideration for the need of the U.S. to conserve energy. Additionally, by reducing U.S. participation in global oil markets, fuel economy standards also improve U.S. energy security and our national balance of payments. Again, by reducing the most fuel consumed, Alternative PC6LT8 would likely best serve the need of the U.S. to conserve energy in these respects.

With regard to pollution effects, Alternative PC6LT8 would also result in the greatest reduction in CO_2 emissions over time, and thus have the largest (relative) impact on climate change, as assessed against any of the baselines.[1428] The effects of other pollutants are more mixed—while the emissions of NO_X and $PM_{2.5}$ eventually decrease over time, with effects being greater as stringency increases, SO_X emissions could marginally increase by 2050, after significant fluctuation, in all of the alternatives including the No-Action alternative, due to greater use of electricity for PHEVs and BEVs, although differences between the action alternatives are modest and SO_x emissions would be significantly lower than they are at present.[1429] Chapter 8.2.5 of the FRIA discusses estimated environmental effects of the regulatory alternatives in more detail.

These results are a direct consequence of the input assumptions used for this analysis, as well as the uncertainty surrounding these assumptions. However, both relative and absolute effects for NO_X, $PM_{2.5}$, and SO_X under each regulatory alternative are quite small in the context of overall U.S. emissions of these pollutants, and even in the context of U.S. transportation sector emissions of these pollutants. CAFE standards are not a primary driver for these pollutants; the estimated effects instead come largely from potential changes in travel demand that may result from improved fuel economy, rather than from the standards themselves. NHTSA would thus say, generally speaking, that Alternative PC6LT8 likely best meets the need of the U.S. to conserve energy in terms of environmental effects, because it saves the most fuel under either baseline considered, which consequently means that it (1) maximizes consumer savings on fuel costs, (2) reduces a variety of pollutant emissions by the greatest amount, and (3) most reduces U.S. participation in global oil markets, with attendant benefits to energy security and the national balance of payments.

However, even though Alternative PC6LT8 may best meet the need of the U.S. to conserve energy, and even though other regulatory alternatives may also contribute more to the need of the U.S. to conserve energy than the preferred alternative, NHTSA concludes that those other alternatives are beyond maximum feasible in the rulemaking time frame. NHTSA is arriving at this conclusion based on the other factors that we consider, because all of the statutory factors must be considered in determining maximum feasible CAFE standards. The need of the U.S. to conserve energy nearly always works in NHTSA's balancing to push standards more stringent, while other factors may work in the opposite direction.

Specifically, based on the information currently available, NHTSA concludes that the more stringent regulatory alternatives considered in this analysis land past the point of economic practicability in this time frame. In considering economic practicability, NHTSA tries to evaluate where the

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[1427] *See* Table V–20 and Table V–21, which illustrate that fuel savings increase for passenger cars and light trucks as alternative-stringency increases under both model year and calendar year accounting methods.

[1428] *See* Table V–23, which illustrates that CO_2 emissions are further reduced as alternative-stringency increases, with PC6LT8 reducing the most CO_2 over time.

[1429] *See* Section V.C of the preamble above for more discussion on these analytical results, as well as FRIA Chapter 8.2 and Chapter 4 of the EIS.

tipping point in the balancing of factors might be through a variety of metrics and considerations, examined in more detail below.

We underscore again that the modeling analysis does not dictate the ''answer,'' it is merely one source of information among others that aids NHTSA's balancing of the standards. We similarly underscore that there is no single bright line beyond which standards might be economically impracticable, and that these metrics are not intended to suggest one; they are simply ways to think about the information before us. The discussion of trying to identify a ''tipping point'' is simply an attempt to grapple with the information, and the ultimate decision rests with the decision-maker's discretion.

While the need of the U.S. to conserve energy may encourage NHTSA to be more technology-forcing in its balancing, regulatory alternatives that can only be achieved by the extensive application of advanced technologies besides BEVs are not economically practicable in the MY 2027–2031 time frame and are thus beyond maximum feasible. Technology application can be considered as ''which technologies, and when''—both the technologies that NHTSA's analysis suggests would be used, and how that application occurs given manufacturers' product lifecycles. It is crucially important to remember that NHTSA's decision-making with regard to economic practicability and what standards are maximum feasible overall must be made in the context of the 32902(h) restrictions against considering the fuel economy of BEVs and the full fuel economy of PHEVs. Our results comply with those restrictions, and it is those results that inform NHTSA's decision-making.

Additionally, as discussed in Section VI.A, NHTSA concludes in this final rule that many of the alternatives are beyond technologically feasible considering the technologies available to be considered under the statutorily-constrained analysis, and the constraints of planned redesign cycles, a point that was not a concern in prior rulemakings due to the state of technology development at that time. NHTSA has historically understood technological feasibility as referring to whether a particular method of improving fuel economy is available for deployment in commercial application in the model year for which a standard is being established. While all of the technology in NHTSA's analysis is already available for deployment, the statutory requirement to exclude fuel economy improvements due to BEVs (and the full fuel economy of PHEVs) from consideration of maximum feasible standards means that NHTSA must focus on technology available to improve the fuel economy of ICEs, and on the remaining vehicles that are not yet anticipated to be fully electric during the rulemaking time frame. Many commenters agreed that when these forms of electrification were excluded, more stringent standards were not technologically feasible considering the technologies available to be considered under the statutorily-constrained analysis and the constraints of planned redesign cycles.

In terms of the levels of technology required and which technologies those may be, NHTSA's analysis estimates manufacturers' product ''cadence,'' representing them in terms of estimated schedules for redesigning and ''freshening'' vehicles, and assuming that significant technology changes will be implemented during vehicle redesigns—as they historically have been. Once applied, a technology will be carried forward to future model years until superseded by a more advanced technology, if one exists that NHTSA can consider in the statutorily-constrained analysis. If manufacturers are already applying technology widely and intensively to meet standards in earlier years, then during the model years subject to the rulemaking more technology may simply be unavailable to apply (having already been applied or being statutorily prohibited for purposes of NHTSA's analysis), or redesign opportunities may be very limited, causing manufacturers to fail to comply and making standards less economically practicable.

In the rulemaking time frame, running out of available technology is the fundamental issue that distinguishes the regulatory alternatives. Per-vehicle cost,[1430] according to the analysis, is relatively low as compared to what NHTSA determined was tolerable in prior rounds of rulemaking for both cars and trucks, for most alternatives in most model years, compared to the reference baseline or the No ZEV alternative baseline, although some manufacturers are affected more than others, and sales and employment effects are minimal and not dispositive.[1431] Some commenters noted that per-vehicle costs for the proposal were lower than what NHTSA had considered to be still within the range of economic practicability in prior rules. NHTSA agrees that this is the case and recognizes that the per-vehicle costs for the final rule are significantly lower than for the proposal, but NHTSA also recognizes manufacturer concerns with retaining all available capital and resources for the technology transition that NHTSA cannot consider directly.

The tables below show additional regulatory (estimated technology plus estimated civil penalties) costs estimated to be incurred under each action alternative as compared to the No-Action Alternative, given the statutory restrictions under which NHTSA conducts its ''standard setting'' analysis:

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[1430] Because our analysis includes estimates of manufacturers' indirect costs and profits, as well as civil penalties that some manufacturers (as allowed under EPCA/EISA) might choose to pay in lieu of achieving compliance with CAFE standards, we report cost increases as estimated average increase in vehicle price (as MSRP). NHTSA does not expect that the prices of every vehicle would increase by the same amount; rather, the agency's underlying analysis shows unit costs varying widely between different vehicle models, as evident in the model output available on NHTSA's website. While we recognize that manufacturers will distribute regulatory costs throughout their fleet to maximize profit, we have not attempted to estimate strategic pricing as requested by some commenters, having insufficient data (which would likely be CBI) on which to base such an attempt. Additionally, even recognizing that manufacturers will distribute regulatory costs throughout their fleets, NHTSA still believes that average per-vehicle cost is useful for illustrating the possible broad affordability implications of new standards.

The technology costs described here are what NHTSA elsewhere calls ''regulatory costs,'' which means the combination of additional costs of technology added to meet the standards, plus any civil penalties paid in lieu of meeting standards. This is not an assessment that manufacturers *will* pay civil penalties, it is simply an assumption for purposes of this analysis and subject to its constraints that some manufacturers *could choose* to pay civil penalties rather than apply additional technology if they deem that approach more cost-effective. Manufacturers are always free to choose their own compliance path.

[1431] See Section V.A. and FRIA 8.2.2 and 8.2.7.

Figure VI-11: Estimated Average Price Change (Regulatory Cost) for Passenger Cars (2021$, vs. No-Action Alternative)

	PC2LT002					PC1LT3					PC2LT4					PC3LT5					PC6LT8				
Model Year	27	28	29	30	31	27	28	29	30	31	27	28	29	30	31	27	28	29	30	31	27	28	29	30	31
BMW	-20	21	70	93	-15	60	159	233	254	-39	131	300	416	511	278	176	436	688	892	705	319	910	1545	2057	2157
Ford	701	690	683	701	648	399	389	385	379	548	702	690	683	841	1101	832	819	810	1246	1567	832	1126	1461	2346	2959
GM	137	192	1156	1354	1319	312	578	1063	1247	1159	385	757	1664	1901	1955	480	964	1865	2255	3139	730	1582	2678	3442	4505
Honda	559	511	463	413	256	86	67	47	23	-103	71	53	33	11	-115	538	544	514	425	257	832	1212	1584	1547	1590
Hyundai	308	300	487	462	485	119	113	201	241	272	308	300	487	461	437	379	370	806	788	1017	1443	1860	2490	3015	3369
JLR	-123	-119	243	522	92	-75	287	609	766	401	-10	431	805	1126	847	70	576	1015	1398	1191	300	1028	1688	2310	2373
Karma	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KIA	85	1093	1901	1911	1798	147	280	526	402	416	217	1238	2175	1980	1801	315	1415	2517	2433	2145	590	2038	3307	3361	3301
Lucid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mazda	226	319	416	384	344	215	200	189	172	148	224	310	416	383	344	248	348	648	597	542	327	562	8780	7997	7271
Mercedes-Benz	-130	-171	-65	-166	-177	-48	23	141	53	30	-12	108	257	232	233	28	194	399	477	507	164	474	902	1534	1754
Mitsubishi	-22	59	57	62	144	-22	0	-1	4	9	-22	59	57	62	78	-22	122	118	326	363	112	986	972	1223	1354
Nissan	-7	17	155	206	225	71	0	49	26	18	106	85	285	272	252	144	258	570	545	587	333	948	1572	1813	2262
Rivian	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stellantis	-16	135	289	398	454	-36	450	439	703	772	-18	587	666	1036	1201	47	765	933	1413	1662	417	1398	1846	2616	3072
Subaru	-91	-103	-107	-113	-119	-92	-104	-108	-114	-119	-92	-104	-108	-114	-120	-92	-103	-108	-61	-71	180	117	230	383	337
Tesla	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Toyota	-57	-65	-78	-87	-199	-60	-73	-80	-91	-204	-35	-66	-60	6	-168	29	57	148	288	76	230	636	1123	1793	1970
Volvo	-151	-149	-146	-144	-142	-151	-97	56	-144	11	-151	-33	159	-27	160	-151	44	259	173	409	-151	219	517	807	1200
VWA	18	447	524	519	444	94	504	640	581	404	197	814	928	975	886	303	1031	1208	1361	1346	612	1505	2014	2534	2789
Industry Avg.	135	227	398	413	357	72	134	212	220	168	127	278	471	506	450	246	455	724	812	848	537	1072	1650	2036	2303

Figure VI-12: Estimated Average Price Change (Regulatory Cost) for Light Trucks (2021$, vs. No-Action Alternative)

	PC2LT002					PC1LT3					PC2LT4					PC3LT5					PC6LT8				
Model Year	27	28	29	30	31	27	28	29	30	31	27	28	29	30	31	27	28	29	30	31	27	28	29	30	31
BMW	0	60	82	67	49	72	260	334	373	439	105	328	453	545	637	131	403	666	760	877	231	809	1496	2061	2458
Ford	41	238	346	350	373	509	859	1097	1081	1161	509	859	1097	1204	1501	509	859	1097	1482	1887	509	1148	1670	2516	3282
GM	445	457	513	615	1731	542	704	855	1056	2209	583	820	1016	1293	2512	639	958	1194	1614	2881	791	1392	1913	2696	4301
Honda	40	38	36	33	31	-12	19	90	122	113	143	265	346	563	519	233	398	490	792	732	443	633	954	1305	1558
Hyundai	-2	40	141	220	159	241	400	594	722	692	405	562	831	1005	995	645	846	1226	3480	4198	669	1201	1705	4521	5564
JLR	1	2	265	383	130	44	391	750	975	3004	102	541	971	1279	3413	174	691	1209	1619	3826	391	1171	1979	2756	5317
Karma	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KIA	44	304	344	382	376	108	525	650	1021	1026	169	615	827	6116	5769	251	759	1090	6309	6136	486	1275	1952	7315	7034
Lucid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mazda	-9	-58	-61	-62	-183	-11	-68	-59	-56	-178	17	-33	228	276	130	134	91	627	725	547	4728	4518	5235	7612	6814
Mercedes-Benz	-36	-37	18	164	-19	86	249	375	540	356	128	331	504	722	585	172	415	654	943	871	312	703	1229	2222	2524
Mitsubishi	-1	28	27	33	36	-1	34	34	40	43	-1	34	34	165	340	-1	185	182	450	609	78	1334	1317	1590	1781
Nissan	-5	100	256	150	6	93	685	800	855	675	123	877	1110	1320	1117	154	984	1287	1523	1298	317	1374	1879	2324	2492
Rivian	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stellantis	304	326	354	486	416	251	478	520	815	862	348	647	748	1121	1212	428	804	976	1452	1615	624	1258	1695	2529	3039
Subaru	-14	-23	-28	-35	-120	-15	-25	-31	-37	-122	-15	-8	4	42	-50	-14	87	204	317	239	164	572	956	1369	1168
Tesla	-284	-283	-279	-274	-270	-284	-283	-279	-274	-270	-284	-283	-279	-274	-270	-284	-283	-279	-274	-270	-284	-283	-279	-274	-270
Toyota	2	-3	-5	-7	-8	4	30	81	140	130	27	275	358	453	462	76	367	517	646	809	221	734	1162	1503	1854
Volvo	-16	-16	-16	296	255	-16	71	353	603	800	-16	183	552	920	1188	-16	320	752	1192	1577	122	770	1456	2405	3231
VWA	73	87	177	344	260	135	335	531	787	744	190	452	674	1025	1026	259	562	881	1346	1421	476	921	1656	2524	3005
Industry Avg.	126	176	224	272	409	226	410	523	643	835	276	538	694	1039	1277	330	646	862	1395	1730	541	1096	1581	2472	3065

Figure VI-13: Estimated Average Price Change (Regulatory Cost) for Passenger Cars, No ZEV Alternative Baseline (2021$, vs. No-Action Alternative)

	PC2LT002					PC1LT3					PC2LT4					PC3LT5					PC6LT8				
Model Year	27	28	29	30	31	27	28	29	30	31	27	28	29	30	31	27	28	29	30	31	27	28	29	30	31
BMW	1	86	291	675	611	1	137	332	661	626	1	217	600	1039	1067	27	367	899	1399	1521	231	992	1800	2638	3113
Ford	848	834	825	841	801	717	705	697	688	730	848	834	825	974	1233	848	834	825	1311	1675	875	1166	1599	2544	3223
GM	137	192	1156	1354	1457	312	578	1063	1245	1228	385	757	1664	1900	2045	479	963	1865	2254	3195	729	1582	2678	3442	4599
Honda	-572	-283	-43	-50	-180	-522	-322	-211	-254	-311	-550	-214	138	62	133	-451	1	451	426	525	252	1593	2062	2180	2363
Hyundai	206	200	576	521	609	119	113	324	310	416	228	221	576	520	784	444	479	1010	934	1210	1491	1929	2570	3139	3821
JLR	-118	-115	210	596	365	-84	287	595	900	778	-17	437	798	1157	1112	64	584	1014	1435	1466	300	1046	1702	2367	2673
Karma	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KIA	69	1074	1887	1929	1929	131	317	619	522	534	202	1240	2171	2124	2013	299	1422	2502	2476	2447	574	2039	3296	3506	3687
Lucid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mazda	108	156	2851	2833	2797	-58	-67	288	283	337	108	156	772	760	751	108	297	9769	9468	8992	228	1167	10364	10530	10830
Mercedes-Benz	-128	-168	-25	-133	27	-41	22	150	116	259	-2	110	290	312	490	60	219	431	553	834	163	475	913	1625	2122
Mitsubishi	-10	157	155	283	353	-22	125	123	150	177	-1	356	351	396	446	122	267	264	524	609	496	1039	1026	1576	2153
Nissan	32	155	280	511	588	75	43	122	293	285	147	211	340	562	645	227	319	630	785	1072	457	1017	1646	2043	2761
Rivian	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stellantis	-14	121	298	493	839	207	556	610	880	1085	337	771	910	1251	1507	438	964	1200	1621	1910	772	1549	2049	2752	3252
Subaru	-108	-114	1186	1182	1168	150	13	-112	-110	-108	251	207	-112	-110	-108	360	414	64	63	63	609	1204	1503	1423	2086
Tesla	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Toyota	-42	93	224	634	677	-52	-14	158	512	422	-10	218	522	1056	1064	54	381	806	1532	1771	330	1020	1805	2818	3383
Volvo	-105	-74	-7	35	200	-39	43	93	301	419	-12	108	191	454	595	23	174	287	601	807	125	386	599	1272	1625
VWA	18	323	421	571	671	106	389	534	714	857	209	698	822	1094	1244	314	914	1102	1476	1702	623	1390	1909	2651	3157
Industry Avg.	-26	146	454	594	629	10	108	263	379	384	62	311	628	799	884	148	469	925	1168	1407	518	1244	1912	2443	2948

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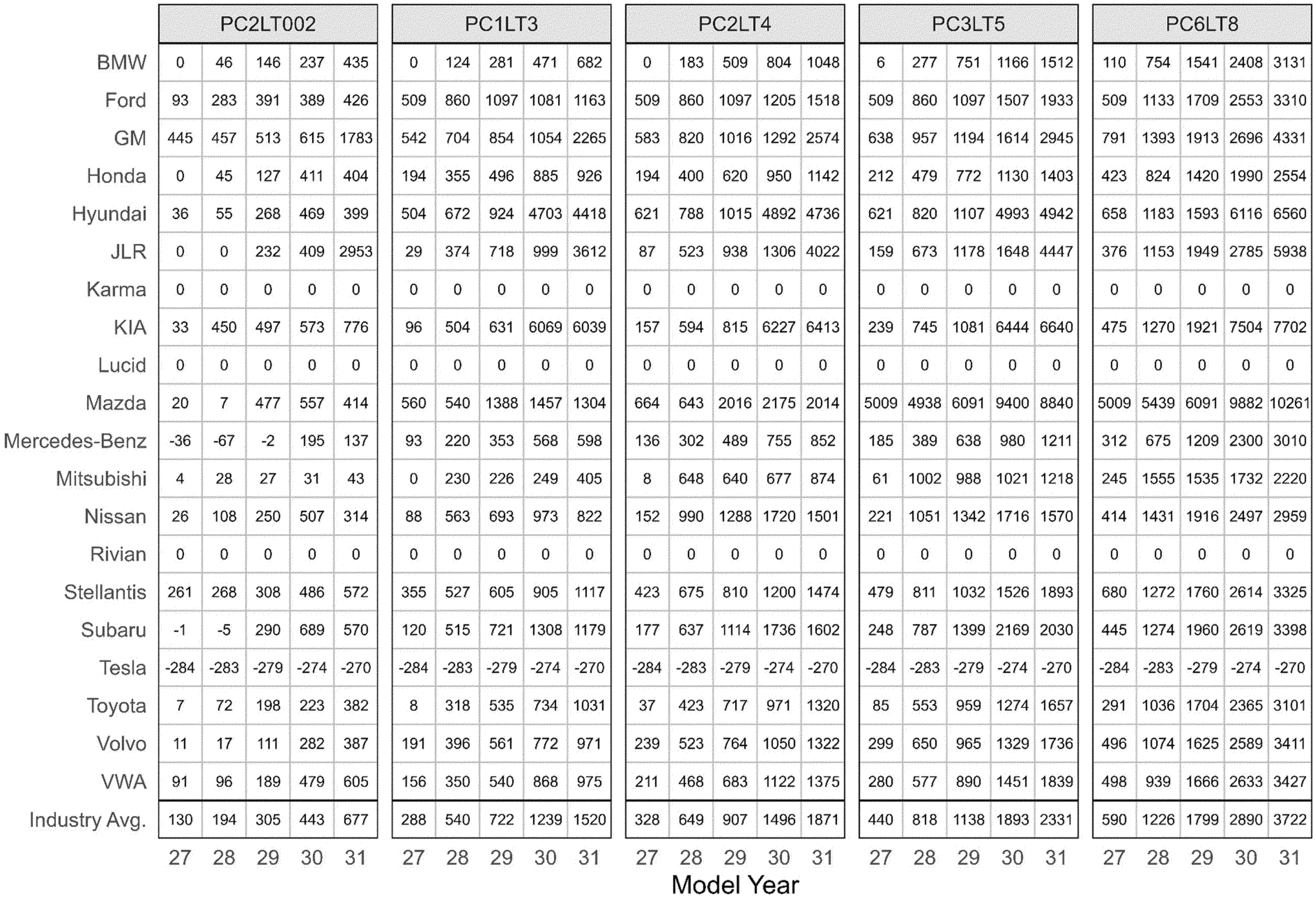
Figure VI-14: Estimated Average Price Change (Regulatory Cost) for Light Trucks, No ZEV Alternative Baseline (2021$, vs. No-Action Alternative)



	PC2LT002					PC1LT3					PC2LT4					PC3LT5					PC6LT8				
	27	28	29	30	31	27	28	29	30	31	27	28	29	30	31	27	28	29	30	31	27	28	29	30	31
BMW	0	46	146	237	435	0	124	281	471	682	0	183	509	804	1048	6	277	751	1166	1512	110	754	1541	2408	3131
Ford	93	283	391	389	426	509	860	1097	1081	1163	509	860	1097	1205	1518	509	860	1097	1507	1933	509	1133	1709	2553	3310
GM	445	457	513	615	1783	542	704	854	1054	2265	583	820	1016	1292	2574	638	957	1194	1614	2945	791	1393	1913	2696	4331
Honda	0	45	127	411	404	194	355	496	885	926	194	400	620	950	1142	212	479	772	1130	1403	423	824	1420	1990	2554
Hyundai	36	55	268	469	399	504	672	924	4703	4418	621	788	1015	4892	4736	621	820	1107	4993	4942	658	1183	1593	6116	6560
JLR	0	0	232	409	2953	29	374	718	999	3612	87	523	938	1306	4022	159	673	1178	1648	4447	376	1153	1949	2785	5938
Karma	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KIA	33	450	497	573	776	96	504	631	6069	6039	157	594	815	6227	6413	239	745	1081	6444	6640	475	1270	1921	7504	7702
Lucid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mazda	20	7	477	557	414	560	540	1388	1457	1304	664	643	2016	2175	2014	5009	4938	6091	9400	8840	5009	5439	6091	9882	10261
Mercedes-Benz	-36	-67	-2	195	137	93	220	353	568	598	136	302	489	755	852	185	389	638	980	1211	312	675	1209	2300	3010
Mitsubishi	4	28	27	31	43	0	230	226	249	405	8	648	640	677	874	61	1002	988	1021	1218	245	1555	1535	1732	2220
Nissan	26	108	250	507	314	88	563	693	973	822	152	990	1288	1720	1501	221	1051	1342	1716	1570	414	1431	1916	2497	2959
Rivian	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stellantis	261	268	308	486	572	355	527	605	905	1117	423	675	810	1200	1474	479	811	1032	1526	1893	680	1272	1760	2614	3325
Subaru	-1	-5	290	689	570	120	515	721	1308	1179	177	637	1114	1736	1602	248	787	1399	2169	2030	445	1274	1960	2619	3398
Tesla	-284	-283	-279	-274	-270	-284	-283	-279	-274	-270	-284	-283	-279	-274	-270	-284	-283	-279	-274	-270	-284	-283	-279	-274	-270
Toyota	7	72	198	223	382	8	318	535	734	1031	37	423	717	971	1320	85	553	959	1274	1657	291	1036	1704	2365	3101
Volvo	11	17	111	282	387	191	396	561	772	971	239	523	764	1050	1322	299	650	965	1329	1736	496	1074	1625	2589	3411
VWA	91	96	189	479	605	156	350	540	868	975	211	468	683	1122	1375	280	577	890	1451	1839	498	939	1666	2633	3427
Industry Avg.	130	194	305	443	677	288	540	722	1239	1520	328	649	907	1496	1871	440	818	1138	1893	2331	590	1226	1799	2890	3722

Model Year

The figures above illustrate clearly that results vary by manufacturer, by year, and by fleet. NHTSA typically considers average results for a metric like per-vehicle cost, in part because NHTSA has typically approached economic practicability as a question for the industry as a whole, such that standards can still be maximum feasible even if they are harder for some manufacturers than others.[1432] The average passenger car cost increase under PC6LT8 is $537 in model year 2027 but rises rapidly thereafter, exceeding $2,300 by model year 2031. In contrast, the average passenger car cost increase under PC2LT002 reaches only $409 by model year 2031. This is a fairly stark difference between the least and most stringent action alternatives. Industry average passenger car costs are lower for PC1LT3 than for PC2LT002, as might be assumed given the slower rate of increase, but the increase for model years 2029–2031 passenger cars under PC2LT4 as compared to PC2LT002 is about $100 more per vehicle in any given model year, even though the rate of increase—2 percent per year for passenger cars—is the same for both alternatives. This is largely a function of higher average civil penalties for light trucks under LT4 being distributed across all of a manufacturer's fleets, rather than an inherent difference in passenger car technology costs under the two different PC2 alternatives. NHTSA believes that this approach to distributing civil penalties is reasonable, even though manufacturers may have different pricing strategies in the real world, but we lack more precise information to target penalty distribution more specifically and invite manufacturers to share whatever information might increase the specificity of our assumptions for future rounds of rulemaking. Industry average passenger car costs for PC3LT5 are nearly double those for PC2LT002 and PC2LT4. Under the No ZEV alternative baseline, average passenger car costs are higher for every alternative, ranging from $384 for PC1LT3 in MY 2031, to $2,948 for PC6LT8 in MY 2031. As under the reference baseline, industry average passenger car costs for PC3LT5 are nearly double those for PC2LT002 and PC2LT4, and PC2LT4 is slightly more expensive than PC2LT002 due to distribution of civil penalties as discussed above.

For light trucks, the average light truck cost increase under PC6LT8 is $541 in model year 2027, and (similarly to cars) rises rapidly thereafter, exceeding $3,000 by model year 2031. In contrast, the average light truck cost increase under PC2LT002 reaches only $409 by model year 2032. As for cars, this is a fairly stark difference between these alternatives. Comparing average light truck cost increases between PC2LT002 and PC1LT3, industry average light truck costs more than double, and model year 2031 industry average light truck costs for PC2LT4 are triple those for PC2LT002. Under the No ZEV alternative baseline, average light truck costs are higher for every alternative, ranging from $677 for PC2LT002 in MY 2031, to $3,722 for PC6LT8 in MY 2031. As under the reference baseline, industry average light truck costs increase fairly rapidly as stringency increases. As discussed in Section VI.A, while NHTSA has no bright-line rule regarding the point at which per-vehicle cost becomes economically impracticable, when considering the stringency increases (and attendant costs) that manufacturers will be facing over the period immediately prior to these standards, in the form of the model years 2024–2026 standards, NHTSA has concluded that the over-$3,000 per vehicle estimated for PC6LT8 by model year 2032 is too much. model year 2031 average costs for PC2LT4 and PC3LT5 are more in line with the levels of per-vehicle costs that NHTSA has considered to be economically practicable over the last dozen years of rulemakings.

However, average results may be increasingly somewhat misleading as manufacturers transition their fleets to the BEVs whose fuel economy NHTSA is prohibited from considering when setting the standards. This is because fuel economy in the fleet has historically been more of a normal distribution (*i.e.,* a bell curve), and with more and more BEVs, it becomes more of a bimodal distribution (*i.e.,* a two-peak curve). Attempting to average a bimodal distribution does not necessarily give a clear picture of what non-BEV-specialized manufacturers are capable of doing, and regardless, NHTSA is directed not to consider BEV fuel economy. Thus, examining individual manufacturer results more closely may be more illuminating, particularly the results for the manufacturers who have to deploy the most technology to meet the standards.

Looking at per-manufacturer results for passenger cars, under PC6LT8, nearly every non-BEV-only manufacturer would exceed more than $2,000 per passenger car in regulatory costs by model year 2031 under the reference baseline analysis, with higher costs (over $3,000) for GM, Hyundai, Kia, Mazda, and Stellantis. Costs are somewhat higher under the No ZEV alternative baseline than under the reference baseline, as shown in Section VI.A above. In the standard-setting analysis which NHTSA must consider here, significant levels of advanced MR, SHEV, and advanced engine technologies tend to be driving many of these cost increases. These changes are best understood in context—passenger car sales have been falling over recent years while prices have been rising, and most of the new vehicles sold in the last couple of years have been more expensive models.[1433] NHTSA does not want to inadvertently burden passenger car sales by requiring too much additional cost for new vehicles, particularly given the performance of the passenger car fleet in comparison to the light truck fleet in terms of mileage gains; every mile driven in passenger cars is, on average, more fuel-efficient than miles driven in light trucks. While the costs of PC2LT002 or PC2LT4 may challenge some manufacturers of passenger cars, they will generally do so by much less than PC3LT5.[1434]

Looking at per-manufacturer results for light trucks, under PC6LT8, every non-BEV-only manufacturer but Subaru and Toyota would exceed $2,000 in per-vehicle costs by model year 2031, with nearly all of those exceeding $3,000. This is likely due to a combination of high MR levels, advanced engines, advanced transmissions, SHEV, and (for PC6LT8, particularly) PHEV technologies being applied to trucks in order to meet PC6LT8. The only alternative with no manufacturer exceeding $2,000 in any model year under the reference baseline analysis is PC2LT002, because GM exceeds $2,000 in model year 2031 under PC1LT3. Costs are somewhat higher under the No ZEV alternative baseline than under the reference baseline, as shown in Section VI.A above, with JLR exceeding $2,000 in MY 2031 even under PC2LT002. Again, this is not to say that $2,000 is a bright line threshold for economic practicability, but simply to recognize that manufacturers, including GM and

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[1432] *See, e.g.,* 87 FR at 25969 (''If the overarching purpose of EPCA is energy conservation, NHTSA believes that it is reasonable to expect that maximum feasible standards may be harder for some automakers than for others, and that they need not be keyed to the capabilities of the least capable manufacturer. Indeed, keying standards to the least capable manufacturer may disincentivize innovation by rewarding laggard performance.'').

[1433] Tucker, S.2021. Automakers Carry Tight Inventories: What Does It Mean to Car Buyers? Kelly Blue Book. Available at: *https://www.kbb.com/car-advice/automakers-carry-tight-inventories-what-does-it-mean-to-car-buyers/.* (Accessed: Feb. 28, 2024).

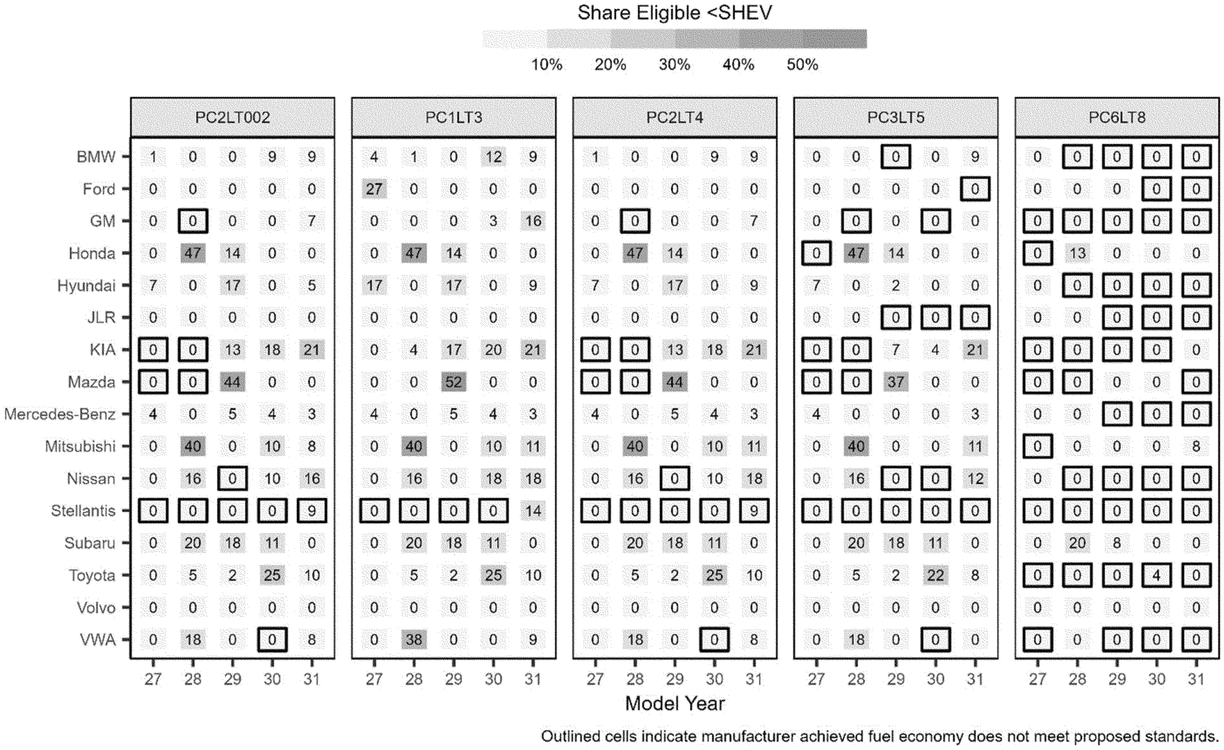
[1434] This is particularly true for a manufacturer like GM who clearly struggles in the statutorily-constrained analysis to control costs as alternative stringency increases.

JLR, commented extensively about the need to retain resources for the technological transition that NHTSA cannot consider directly. NHTSA *may* consider availability of resources, and NHTSA would not want CAFE standards to complicate manufacturer efforts to save more fuel in the longer term by diverting resources in the shorter term.

As discussed above, this is particularly the case for civil penalty payment—during this rulemaking time frame, given the technological transition underway, NHTSA agrees with industry commenters that civil penalty payments resulting from CAFE non-compliance would divert needed resources from that transition without conserving additional energy. NHTSA has typically considered shortfalls in the context of economic practicability, but as discussed in Section VI.A, as the fleet approaches the technological limits of what NHTSA may consider by statute in setting standards, manufacturers appearing in the analysis to run out of technology may increasingly be an issue of technological feasibility as well. Some commenters suggested that NHTSA was conflating these two factors in considering them this way, btu NHTSA believes it is still giving full effect to all relevant factors even if they begin to blend somewhat as the world changes and as the statutory constraints become more constraining on NHTSA's ability to account for the real world in its decision-making.

Section VI.A discussed the phenomenon in the analysis that manufacturers attempting to comply with future CAFE standards could ''run out of technology'' just because opportunities were lacking to redesign enough of their vehicles consistent with their normal redesign schedule. NHTSA does not account for the possibility that manufacturers would choose to ''break'' their redesign schedules to keep pace with more stringent standards, in large part because the costs to do so would be significant and NHTSA does not have the information needed to reflect such an effort. The figures below illustrate, for passenger cars and light trucks, how technology application (in this case, SHEVs, which are essentially the end of the powertrain decision tree for purposes of the constrained analysis[1435]) lack of redesign opportunity and manufacturer likelihood of shortfalls interact. The number for any given manufacturer, model year, and regulatory alternative is the portion of the fleet that is lower on the decision trees than SHEV (typically MHEV or ICEV). Cells with boxes around them indicate shortfalls. For nearly every instance where a manufacturer is unable to achieve the standard, their fleet has already been converted to SHEV or above (represented by a darker box with a zero inside).[1436]

Figure VI-15: Share of Fleet Eligible for Redesign to SHEV, Passenger Car



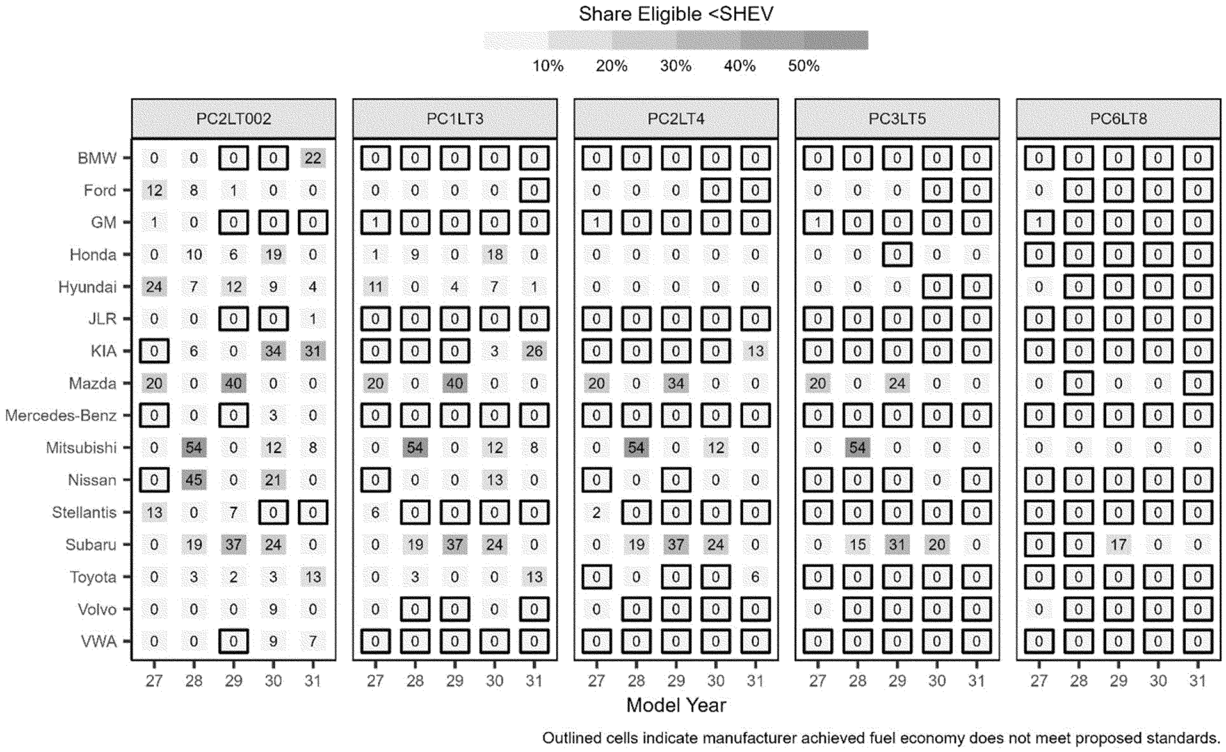
	PC2LT002					PC1LT3					PC2LT4					PC3LT5					PC6LT8				
	27	28	29	30	31	27	28	29	30	31	27	28	29	30	31	27	28	29	30	31	27	28	29	30	31
BMW	1	0	0	9	9	4	1	0	12	9	1	0	0	9	9	0	0	$\boxed{0}$	0	9	0	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
Ford	0	0	0	0	0	27	0	0	0	0	0	0	0	0	0	0	0	0	0	$\boxed{0}$	0	0	0	$\boxed{0}$	$\boxed{0}$
GM	0	$\boxed{0}$	0	0	7	0	0	0	3	16	0	$\boxed{0}$	0	0	7	0	$\boxed{0}$	0	$\boxed{0}$	0	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
Honda	0	47	14	0	0	0	47	14	0	0	0	47	14	0	0	$\boxed{0}$	47	14	0	0	$\boxed{0}$	13	0	0	0
Hyundai	7	0	17	0	5	17	0	17	0	9	7	0	17	0	9	7	0	2	0	0	0	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
JLR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	0	0	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
KIA	$\boxed{0}$	$\boxed{0}$	13	18	21	0	4	17	20	21	$\boxed{0}$	$\boxed{0}$	13	18	21	$\boxed{0}$	$\boxed{0}$	7	4	21	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	0
Mazda	$\boxed{0}$	$\boxed{0}$	44	0	0	0	0	52	0	0	$\boxed{0}$	$\boxed{0}$	44	0	0	$\boxed{0}$	$\boxed{0}$	37	0	0	$\boxed{0}$	$\boxed{0}$	0	0	$\boxed{0}$
Mercedes-Benz	4	0	5	4	3	4	0	5	4	3	4	0	5	4	3	4	0	0	0	3	0	0	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
Mitsubishi	0	40	0	10	8	0	40	0	10	11	0	40	0	10	11	0	40	0	0	11	$\boxed{0}$	0	0	0	8
Nissan	0	16	$\boxed{0}$	10	16	0	16	0	18	18	0	16	$\boxed{0}$	10	18	0	16	$\boxed{0}$	$\boxed{0}$	12	0	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
Stellantis	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{9}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	14	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{9}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
Subaru	0	20	18	11	0	0	20	18	11	0	0	20	18	11	0	0	20	18	11	0	0	20	8	0	0
Toyota	0	5	2	25	10	0	5	2	25	10	0	5	2	25	10	0	5	2	22	8	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{4}$	$\boxed{0}$
Volvo	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VWA	0	18	0	$\boxed{0}$	8	0	38	0	0	9	0	18	0	$\boxed{0}$	8	0	18	0	$\boxed{0}$	0	$\boxed{0}$	0	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$

Outlined cells indicate manufacturer achieved fuel economy does not meet proposed standards.

[1435] Other non-powertrain technologies are, of course, available to manufacturers to apply in the analysis, but in terms of meeting the higher stringency alternatives under the constrained analysis, no other technology besides SHEV is as cost-effective. NHTSA therefore uses SHEVs for this illustration because it is the technology that the model is most likely to choose for manufacturer compliance, even if it is not necessarily the technology path that all manufacturers *will* choose in the future.

[1436] There are a few instances in these illustrations where a manufacturer-fleet combination is not in compliance and appears to have some vehicles eligible for powertrain redesign (as shown with a non-zero value inside the box). These are cases in which compliance logic restricts certain SHEV technology, tech conversion is not cost-effective, or where the domestic fleet is not in compliance but the only vehicles eligble for redesign are in the imported car fleet (or vice versa).

Figure VI-16: Share of Fleet Eligible for Redesign to SHEV, Light Truck

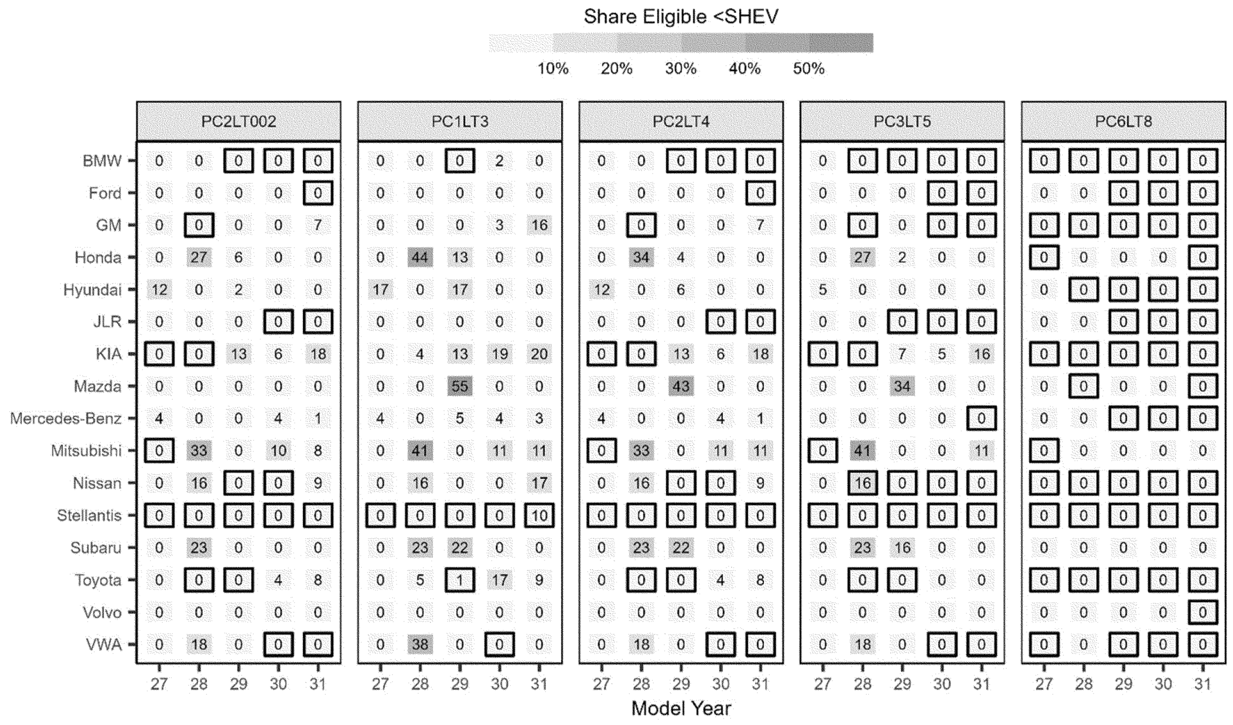


Outlined cells indicate manufacturer achieved fuel economy does not meet proposed standards.

The figures show that for some manufacturers, for some fleets, some shortfalls are almost inevitable (in the constrained analysis) no matter the alternative. In the passenger car fleet, Stellantis clearly would be expected to routinely default to penalty payments under all alternatives but particularly those more stringent than PC2LT002; in the light truck fleet, BMW, GM, Jaguar, Mercedes, Stellantis, and Volkswagen shortfall repeatedly given redesign cycle constraints under all alternatives except PC2LT002, and even under PC2LT002, GM particularly continues to struggle for multiple model years, due to earlier redesigns that responded to the model years 2024–2026 standards and an otherwise relatively long redesign schedule. NHTSA believes that this lends more support to the conclusion that PC2LT002 is maximum feasible.

Shortfall trends are slightly exacerbated for all action alternatives (although results vary by manufacturer) under the No ZEV alternative baseline analysis, as follows:

Figure VI-17: Share of Fleet Eligible for Redesign to SHEV Under No ZEV Alternative Baseline, Passenger Car



PC2LT002

	27	28	29	30	31
BMW	0	0	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
Ford	0	0	0	0	$\boxed{0}$
GM	0	$\boxed{0}$	0	0	7
Honda	0	27	6	0	0
Hyundai	12	0	2	0	0
JLR	0	0	0	$\boxed{0}$	$\boxed{0}$
KIA	$\boxed{0}$	$\boxed{0}$	13	6	18
Mazda	0	0	0	0	0
Mercedes-Benz	4	0	0	4	1
Mitsubishi	$\boxed{0}$	33	0	10	8
Nissan	0	16	$\boxed{0}$	$\boxed{0}$	9
Stellantis	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
Subaru	0	23	0	0	0
Toyota	0	$\boxed{0}$	$\boxed{0}$	4	8
Volvo	0	0	0	0	0
VWA	0	18	0	$\boxed{0}$	$\boxed{0}$

PC1LT3

	27	28	29	30	31
BMW	0	0	$\boxed{0}$	2	0
Ford	0	0	0	0	0
GM	0	0	0	3	16
Honda	0	44	13	0	0
Hyundai	17	0	17	0	0
JLR	0	0	0	0	0
KIA	0	4	13	19	20
Mazda	0	0	55	0	0
Mercedes-Benz	4	0	5	4	3
Mitsubishi	0	41	0	11	11
Nissan	0	16	0	0	17
Stellantis	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{10}$
Subaru	0	23	22	0	0
Toyota	0	5	$\boxed{1}$	17	9
Volvo	0	0	0	0	0
VWA	0	38	0	$\boxed{0}$	0

PC2LT4

	27	28	29	30	31
BMW	0	0	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
Ford	0	0	0	0	$\boxed{0}$
GM	0	$\boxed{0}$	0	0	7
Honda	0	34	4	0	0
Hyundai	12	0	6	0	0
JLR	0	0	0	$\boxed{0}$	$\boxed{0}$
KIA	$\boxed{0}$	$\boxed{0}$	13	6	18
Mazda	0	0	43	0	0
Mercedes-Benz	4	0	0	4	1
Mitsubishi	$\boxed{0}$	33	0	11	11
Nissan	0	16	$\boxed{0}$	$\boxed{0}$	9
Stellantis	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
Subaru	0	23	22	0	0
Toyota	0	$\boxed{0}$	$\boxed{0}$	4	8
Volvo	0	0	0	0	0
VWA	0	18	0	$\boxed{0}$	$\boxed{0}$

PC3LT5

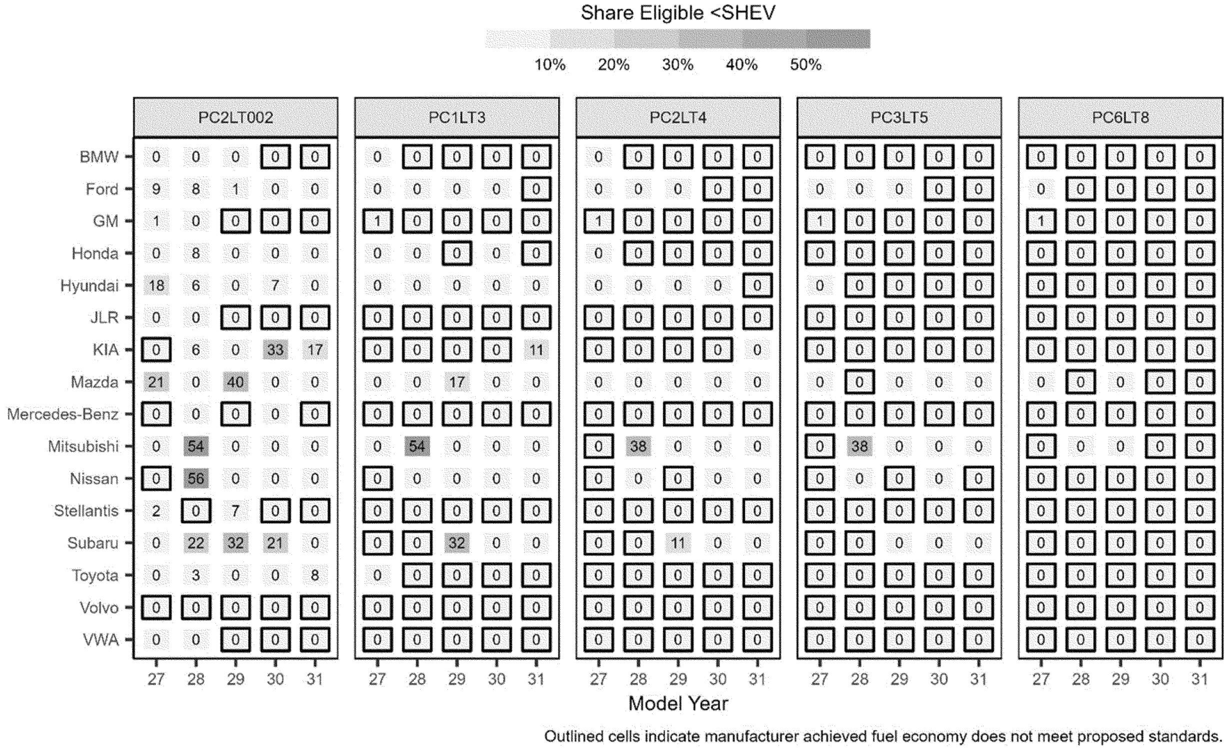
	27	28	29	30	31
BMW	0	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
Ford	0	0	0	$\boxed{0}$	$\boxed{0}$
GM	0	$\boxed{0}$	0	$\boxed{0}$	$\boxed{0}$
Honda	0	27	2	0	0
Hyundai	5	0	0	0	0
JLR	0	0	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
KIA	$\boxed{0}$	$\boxed{0}$	7	5	16
Mazda	0	0	34	0	0
Mercedes-Benz	0	0	0	0	$\boxed{0}$
Mitsubishi	$\boxed{0}$	41	0	0	11
Nissan	0	$\boxed{16}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
Stellantis	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
Subaru	0	23	16	0	0
Toyota	0	$\boxed{0}$	$\boxed{0}$	0	0
Volvo	0	0	0	0	0
VWA	0	18	0	$\boxed{0}$	$\boxed{0}$

PC6LT8

	27	28	29	30	31
BMW	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
Ford	0	0	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
GM	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
Honda	$\boxed{0}$	0	0	0	$\boxed{0}$
Hyundai	0	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
JLR	0	0	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
KIA	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
Mazda	0	$\boxed{0}$	0	0	$\boxed{0}$
Mercedes-Benz	0	0	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
Mitsubishi	$\boxed{0}$	0	0	0	0
Nissan	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
Stellantis	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
Subaru	0	0	0	0	0
Toyota	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
Volvo	0	0	0	0	$\boxed{0}$
VWA	$\boxed{0}$	0	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$

Outlined cells indicate manufacturer achieved fuel economy does not meet proposed standards.

Figure VI-18: Share of Fleet Eligible for Redesign to SHEV Under No ZEV Alternative Baseline, Light Truck



PC2LT002	27	28	29	30	31
BMW	0	0	0	$\boxed{0}$	$\boxed{0}$
Ford	9	8	1	0	0
GM	1	0	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
Honda	0	8	0	0	0
Hyundai	18	6	0	7	0
JLR	0	0	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
KIA	$\boxed{0}$	6	0	33	17
Mazda	21	0	40	0	0
Mercedes-Benz	$\boxed{0}$	0	$\boxed{0}$	0	$\boxed{0}$
Mitsubishi	0	54	0	0	0
Nissan	$\boxed{0}$	56	0	0	0
Stellantis	2	$\boxed{0}$	7	$\boxed{0}$	$\boxed{0}$
Subaru	0	22	32	21	0
Toyota	0	3	0	0	8
Volvo	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
VWA	0	0	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$

PC1LT3	27	28	29	30	31
BMW	0	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
Ford	0	0	0	0	$\boxed{0}$
GM	$\boxed{1}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
Honda	0	0	$\boxed{0}$	0	$\boxed{0}$
Hyundai	0	0	0	0	0
JLR	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
KIA	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	11
Mazda	0	0	17	0	0
Mercedes-Benz	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
Mitsubishi	0	54	0	0	0
Nissan	$\boxed{0}$	0	0	0	0
Stellantis	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
Subaru	$\boxed{0}$	$\boxed{0}$	32	0	0
Toyota	0	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
Volvo	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
VWA	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$

PC2LT4	27	28	29	30	31
BMW	0	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
Ford	0	0	0	$\boxed{0}$	$\boxed{0}$
GM	$\boxed{1}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
Honda	0	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
Hyundai	0	0	0	0	$\boxed{0}$
JLR	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
KIA	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	0
Mazda	0	0	0	0	0
Mercedes-Benz	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
Mitsubishi	$\boxed{0}$	38	0	0	0
Nissan	$\boxed{0}$	0	$\boxed{0}$	0	0
Stellantis	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
Subaru	$\boxed{0}$	$\boxed{0}$	11	0	0
Toyota	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
Volvo	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
VWA	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$

PC3LT5	27	28	29	30	31
BMW	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
Ford	0	0	0	$\boxed{0}$	$\boxed{0}$
GM	$\boxed{1}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
Honda	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
Hyundai	0	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
JLR	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
KIA	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
Mazda	0	$\boxed{0}$	0	0	0
Mercedes-Benz	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
Mitsubishi	$\boxed{0}$	38	0	0	0
Nissan	$\boxed{0}$	0	$\boxed{0}$	0	$\boxed{0}$
Stellantis	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
Subaru	$\boxed{0}$	$\boxed{0}$	0	0	0
Toyota	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
Volvo	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
VWA	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$

PC6LT8	27	28	29	30	31
BMW	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
Ford	0	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
GM	$\boxed{1}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
Honda	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
Hyundai	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
JLR	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
KIA	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
Mazda	0	$\boxed{0}$	0	$\boxed{0}$	$\boxed{0}$
Mercedes-Benz	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
Mitsubishi	$\boxed{0}$	0	0	$\boxed{0}$	$\boxed{0}$
Nissan	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
Stellantis	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
Subaru	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
Toyota	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
Volvo	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$
VWA	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$	$\boxed{0}$

Outlined cells indicate manufacturer achieved fuel economy does not meet proposed standards.

As under the reference baseline analysis, the figures show that for some manufacturers, for some fleets, shortfalls are almost inevitable (in the constrained analysis) under the No ZEV alternative baseline, no matter the action alternative. In the passenger car fleet, Stellantis would be expected to routinely default to penalty payments under all alternatives; in the light truck fleet, BMW, GM, Jaguar, Mercedes, Stellantis, Volvo, and Volkswagen shortfall repeatedly given redesign constraints under all alternatives except PC2LT002, and even under PC2LT002, GM particularly continues to default to penalty payments for multiple model years, due to earlier redesigns that responded to the model years 2024–2026 standards and an otherwise relatively long redesign schedule. Toyota, Volvo, and Subaru also see powertrain constraints in PC1LT3, where they did not when the alternative was run relative to the reference baseline case. NHTSA believes that this lends more support to the conclusion that PC2LT002 is maximum feasible.

The following tables help to illustrate that in many cases, manufacturers simply lack redesign opportunities during the rulemaking time frame, and as stringency increases across the alternatives, that lack of redesign opportunities becomes more dire in terms of civil penalties consequently owed. ‘‘Share eligible’’ means the percent of this manufacturer's fleet that can be redesigned in this model year and are conventional or MHEV powertrain,[1437] ‘‘compliance position’’ means the mpg amount by which the manufacturer's fleet performance exceeds or falls short of the manufacturer's fleet target, and ‘‘civil penalties’’ means the average amount of civil penalties per vehicle of the passenger car or light truck fleet that the manufacturer would owe as a consequence of a shortfall. These tables provide results estimated versus the reference baseline; results estimated against the No ZEV alternative baseline are generally similar, although some manufacturers' estimated results vary.

[1437] These tables present eligibility results based on powertrain technology, and vehicle powertrain changes are only available at vehicle redesigns. Manufacturers also apply non-powertrain technology to improve vehicle fuel economy, and likely do so in these examples. To simplify the discussion, these changes are omitted from the table and we are only showing technologies that have the highest cost effectiveness, and likely to drive compliance.

Table VI-24: Fleet Status Summary, GM, Light Truck

	2027	2028	2029	2030	2031
PC2LT002					
Share eligible	1%	0%	0%	0%	0%
Compliance position	+0.2	0.0	-0.8	-1.8	-0.9
Civil penalties	-	-	120	278	136
PC1LT3					
Share eligible	1%	0%	0%	0%	0%
Compliance position	-1.0	-2.5	-3.8	-5.3	-4.9
Civil penalties	148	383	570	818	739
PC2LT4					
Share eligible	1%	0%	0%	0%	0%
Compliance position	-1.4	-3.4	-5.1	-7.2	-7.3
Civil penalties	208	521	764	1,111	1,101
PC3LT5					
Share eligible	1%	0%	0%	0%	0%
Compliance position	-1.9	-4.3	-6.5	-9.2	-9.9
Civil penalties	282	659	974	1,420	1,494
PC6LT8					
Share eligible	1%	0%	0%	0%	0%
Compliance position	-3.2	-7.1	-11.2	-15.8	-18.7
Civil penalties	474	1,087	1,679	2,438	2,821

Table VI-25: Fleet Status Summary, Ford, Light Truck

	2027	2028	2029	2030	2031
PC2LT002					
Share eligible	12%	8%	1%	0%	0%
Compliance position	+1.6	+2.3	+2.4	+1.0	0.0
Civil penalties	-	-	-	-	-
PC1LT3					
Share eligible	0%	0%	0%	0%	0%
Compliance position	+2.4	+2.6	+3.2	+1.1	-0.7
Civil penalties	-	-	-	-	106
PC2LT4					
Share eligible	0%	0%	0%	0%	0%
Compliance position	+2.0	+1.7	+1.8	-0.9	-3.2
Civil penalties	-	-	-	139	483
PC3LT5					
Share eligible	0%	0%	0%	0%	0%
Compliance position	+1.5	+0.8	+0.4	-2.9	-5.9
Civil penalties	-	-	-	448	890
PC6LT8					
Share eligible	0%	0%	0%	0%	0%
Compliance position	+0.2	-2.1	-4.3	-9.6	-14.9
Civil penalties	-	322	644	1,481	2,248

Table VI-26: Fleet Status Summary, Stellantis, Light Truck

	2027	2028	2029	2030	2031
PC2LT002					
Share eligible	13%	0%	7%	0%	0%
Compliance position	+0.5	+0.1	+0.7	-0.1	-0.1
Civil penalties	-	-	-	15	15
PC1LT3					
Share eligible	6%	0%	0%	0%	0%
Compliance position	0.0	-1.7	-1.1	-2.3	-3.0
Civil penalties	-	260	165	355	453
PC2LT4					
Share eligible	2%	0%	0%	0%	0%
Compliance position	0.0	-2.2	-2.0	-3.8	-5.1
Civil penalties	-	337	300	586	769
PC3LT5					
Share eligible	0%	0%	0%	0%	0%
Compliance position	-0.2	-2.9	-3.2	-5.7	-7.6
Civil penalties	30	444	480	880	1,147
PC6LT8					
Share eligible	0%	0%	0%	0%	0%
Compliance position	-1.6	-5.9	-8.0	-12.6	-16.8
Civil penalties	237	904	1,199	1,944	2,535

Table VI-27: Fleet Status Summary, Toyota, Light Truck

	2027	2028	2029	2030	2031
PC2LT002					
Share eligible	0%	3%	2%	3%	13%
Compliance position	+1.5	+2.4	+2.6	+2.8	+3.7
Civil penalties	-	-	-	-	-
PC1LT3					
Share eligible	0%	3%	0%	0%	13%
Compliance position	+0.3	0.0	0.0	0.0	+0.3
Civil penalties	-	-	-	-	-
PC2LT4					
Share eligible	0%	0%	0%	0%	6%
Compliance position	-0.2	+0.1	-0.1	-0.6	0.0
Civil penalties	30	-	15	93	-
PC3LT5					
Share eligible	0%	0%	0%	0%	0%
Compliance position	-0.7	-0.9	-1.7	-2.8	-1.4
Civil penalties	104	138	255	432	211
PC6LT8					
Share eligible	0%	0%	0%	0%	0%
Compliance position	-2.2	-4.1	-6.8	-10.1	-11.2
Civil penalties	326	628	1,019	1,559	1,690

Table VI-28: Fleet Status Summary, Toyota, Passenger Car

	2027	2028	2029	2030	2031
PC2LT002					
Share eligible	0%	5%	2%	25%	10%
Compliance position	+2.3	+2.1	+2.0	+2.2	+2.9
Civil penalties	7	15	7	-	-
PC1LT3					
Share eligible	0%	5%	2%	25%	10%
Compliance position	+2.9	+3.4	+4.1	+4.6	+6.0
Civil penalties	-	-	-	-	-
PC2LT4					
Share eligible	0%	5%	2%	25%	10%
Compliance position	+2.3	+2.1	+2.1	+2.5	+3.2
Civil penalties	7	15	7	-	-
PC3LT5					
Share eligible	0%	5%	2%	22%	8%
Compliance position	+1.6	+0.8	+0.2	+0.4	+1.3
Civil penalties	30	61	79	-	-
PC6LT8					
Share eligible	0%	0%	0%	4%	0%
Compliance position	-0.2	-2.3	-4.9	-1.8	-1.3
Civil penalties	100	329	704	394	306

Table VI-29: Fleet Status Summary, Stellantis, Passenger Car

	2027	2028	2029	2030	2031
PC2LT002					
Share eligible	0%	0%	0%	0%	9%
Compliance position	-0.7	-2.4	-2.4	-4.2	-0.9
Civil penalties	105	370	339	618	134
PC1LT3					
Share eligible	0%	0%	0%	0%	14%
Compliance position	-0.1	-1.3	-0.6	-1.8	+0.3
Civil penalties	26	198	67	244	82
PC2LT4					
Share eligible	0%	0%	0%	0%	9%
Compliance position	-0.7	-2.4	-2.4	-4.2	-0.9
Civil penalties	107	370	339	618	136
PC3LT5					
Share eligible	0%	0%	0%	0%	0%
Compliance position	-1.2	-3.6	-4.2	-6.7	-2.8
Civil penalties	181	553	612	1,007	410
PC6LT8					
Share eligible	0%	0%	0%	0%	0%
Compliance position	-3.1	-7.5	-10.3	-15.1	-13.8
Civil penalties	466	1,142	1,520	2,302	2,071

Under the No ZEV alternative baseline analysis, the light truck fleet is more impacted, but not significantly more impacted than under the reference baseline analysis. NHTSA believes that this lends more support to the importance of reducing light truck standard stringency relative to the proposal.

For purposes of the constrained analysis that NHTSA considers for determining maximum feasible standards, manufacturer shortfalls lead necessarily to civil penalties during the model years covered by the rulemaking when manufacturers are prohibited from using credit reserves in a given fleet. As the tables above show, civil penalties increase rapidly as the stringency of regulatory alternatives increase, with some manufacturers facing (in the constrained analysis) penalties of over $2,000 per vehicle for some fleets by model year 2031 under PC6LT8. GM in particular faces penalties of over $1,000 per light truck even under PC2LT4, and roughly an additional $600 per light truck in each model year 2029 through 2031 as stringency increases from PC2LT002 to PC1LT3. For model year 2031 alone, this equates to an increase of $907 million in penalties for GM if NHTSA were to choose PC1LT3 over PC2LT002. Civil penalties for GM increase by a similar magnitude ($895 million) between PC2LT002 and PC1LT3 under the No ZEV alternative baseline. As industry commenters pointed out, civil penalties are resources diverted from the technological transition that NHTSA cannot consider directly—but NHTSA is not prohibited from considering the resources necessary to make that transition, and NHTSA accepts the premise that manufacturers need maximum available resources now to potentially conserve more energy in the longer run. NHTSA has thus also examined civil penalties as a share of regulatory costs as a potential metric for economic practicability in this rulemaking. Table VI–11 and Table VI–12 in Section VI.A.5.a(2) above illustrate civil penalties as a share of regulatory costs for the entire industry for each fleet under each regulatory alternative. NHTSA concluded there that PC2LT002 represents the alternative considered with the lowest economic impacts on manufacturers. With nearly half of light truck manufacturers facing shortfalls under PC1LT3, and over 30 percent of regulatory costs being attributable to civil penalties, given the concerns raised by manufacturers regarding their ability to finance the ongoing technological transition if they must divert funds to paying CAFE penalties, NHTSA believes that PC1LT3 is beyond economically practicable in this particular rulemaking time frame. Given that the proposal, PC2LT4, is even more stringent and results in even higher civil penalties, it too must be beyond economically practicable in this particular rulemaking time frame, when evaluated relative to either the reference baseline analysis or the No ZEV alternative baseline.[1438]

NHTSA received comments from industry stakeholders arguing with NHTSA's reflection of DOE's proposed revisions to the PEF in CAFE analysis. Industry stakeholders expressed concern about the effects of a revised

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[1438] NHTSA recognizes that the Alliance provided extensive comments as to why it believed the stringency of light truck standards should not increase faster than the stringency of passenger car standards. Given NHTSA's decision to reduce the stringency of the light truck standards, NHTSA considers these comments overtaken by events.

PEF value on their CAFE compliance positions,[1439] and stated that NHTSA should reduce the final rule stringency relative to the proposal to account for these effects. In response, NHTSA notes that it cannot consider the fuel economy of BEVs in determining maximum feasible CAFE standards, and the PEF value exists to translate energy consumed by electric and partially-electric vehicles into miles per gallon. NHTSA interprets 49 U.S.C. 32902(h) as therefore expressly prohibiting NHTSA from considering how the PEF revisions affect manufacturers' CAFE compliance positions as part of its determination of new maximum feasible CAFE standards. NHTSA interprets 32902(h) as allowing the agency to consider the *resources* needed to build BEVs *for reasons other than CAFE,* but as prohibiting direct consideration of BEV fuel economy (as calculated using the PEF, whatever the PEF value is) in the standard-setting decision. NHTSA reflects the now-final revised PEF value in the final rule analysis in order to properly calculate manufacturers' reference baseline fuel economy positions but cannot use the revised PEF value as an excuse to set less stringent CAFE standards. NHTSA did conduct a sensitivity analysis run with the prior PEF value,[1440] and found that the manufacturers' relative behavior under the alternatives remained similar to the central analysis. While the specific model results did (predictably) change, the underlying mechanisms as discussed in Section VI.A driving the feasibilities of the alternatives under consideration remained the same. As a result, NHTSA believes the use of the prior PEF value would likely not have produced a change in final standard selection. Moreover, as discussed above, there are adequate reasons in the constrained analysis for NHTSA to find that less stringent standards than the proposal reach the limits of economic practicability in the rulemaking time frame.

As also discussed above and in the TSD and FRIA accompanying this final rule, the No-Action Alternative includes a considerable amount of fuel-saving technology applied in response to (1) the reference baseline (set in 2022) CAFE and CO_2 standards, (2) fuel prices and technology cost-effectiveness (which accounts for recently-developed tax incentives), (3) the California Framework Agreements (albeit only for some intervening model years), (4) ZEV programs in place in California and other States, and (5) manufacturer voluntary deployment of ZEVs consistent with ACC II, regardless of whether it becomes legally binding. The effects of this reference baseline application of technology are not attributable to this action, and NHTSA has therefore excluded these from our estimates of the incremental technology application, benefits, and costs that could result from each action alternative considered here. NHTSA's obligation is to understand and evaluate the effects of *potential future CAFE standards, as compared to* what is happening in the reference baseline. We realize that manufacturers face a combination of regulatory requirements simultaneously, which is why NHTSA seeks to account for those in its analytical reference baseline, and to determine what the additional incremental effects of different potential future CAFE standards would be, within the context of our statutory restrictions. Additionally, for both passenger cars and light trucks, NHTSA notes that in considering the various technology penetration rates for fleets, readers (and NHTSA) must keep in mind that due to the statutory restrictions, NHTSA's analysis considers these technologies as applicable to the remaining ICE vehicles that have not yet electrified for reasons reflected in the reference baseline. This means that the rates apply to only a fraction of each overall fleet, and thus represent a higher rate for that fraction.

However, NHTSA also recognizes that technology applied in the reference baseline, or technological updates made in response to the reference baseline, may limit the technology available to be applied during the rulemaking time frame. As discussed above, if a manufacturer has already widely applied SHEV (for example) in the reference baseline, then the SHEV vehicles cannot be improved further under the constrained analysis. If a manufacturer has redesigned vehicles in order to meet reference baseline obligations and does not have another (or many) redesign opportunity during the rulemaking time frame, then the manufacturer may be unable to meet its CAFE standard and may face civil penalties. NHTSA's final standards, which are less stringent than the proposal, respond to these considerations. So too does NHTSA's analysis of the standards as assessed against the alternative baseline.

With regard to lead time and timing of technology application, NHTSA acknowledges that there is more lead time for these standards than manufacturers had for the model years 2024–2026 standards. That said, NHTSA also recognizes that we have previously stated that if the standards in the years immediately preceding the rulemaking time frame do not require significant additional technology application, then more technology should theoretically be available for meeting the standards during the rulemaking time frame—but this is not necessarily the case here. The SHEV penetration rates shown in Figure VI–15 and Figure VI–16 suggest that, at least for purposes of what NHTSA may consider by statute, industry would be running up against the limits of statutorily-available technology deployment, considering planned redesign cycles, for the more stringent regulatory alternatives, in a way that has not occurred in prior rulemakings. Lead time may not be able to overcome the costs of applying additional technology at a high rate, beyond what is already being applied to the fleet for other reasons during the rulemaking time frame and, in the years immediately preceding it, when considered in the context of the constrained analysis.

As discussed above, when manufacturers do not achieve required fuel economy levels, NHTSA describes them as ''in shortfall.'' NHTSA's analysis reflects several possible ways that manufacturers could fail to meet required fuel economy levels. For some companies that NHTSA judges willing to pay civil penalties in lieu of compliance, usually based on past history of penalty payment, NHTSA assumes that they will do so as soon as it becomes more cost-effective to pay penalties rather than add technology. For other companies whom NHTSA judges unwilling to pay civil penalties, if they have converted all vehicles available to be redesigned in a given model year to SHEV or PHEV and still cannot meet the required standard, then NHTSA does not assume that these companies will break redesign or refresh cycles to convert even more (of the remaining ICE) vehicles to SHEV or PHEV.[1441] In these instances, a manufacturer would be ''in shortfall'' in NHTSA's analysis. Shortfall rates can also be informative for determining economic practicability, because if manufacturers simply are not achieving the required levels, then that suggests that manufacturers have generally judged it more cost-effective *not* to

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[1439] NHTSA has no authority to ''stop'' DOE's process of revising the PEF, as some commenters requested.

[1440] *See* Chapter 9 of the FRIA.

[1441] Ensuring that technology application occurs consistent with refresh/redesign schedules is part of how NHTSA accounts for economic practicability. Forcing technology application outside of those schedules would be neither realistic from a manufacturing perspective nor cost-effective. See Chapter 2.2.1.7 of the TSD for more information about product timing cycles.

comply by adding technology. Moreover, the standards would not be accomplishing what they set out to accomplish, which would mean that the standards are not meeting the need of the U.S. to conserve energy as originally expected.

The following figures illustrate shortfalls by fleet, model year, manufacturer, and regulatory alternative:

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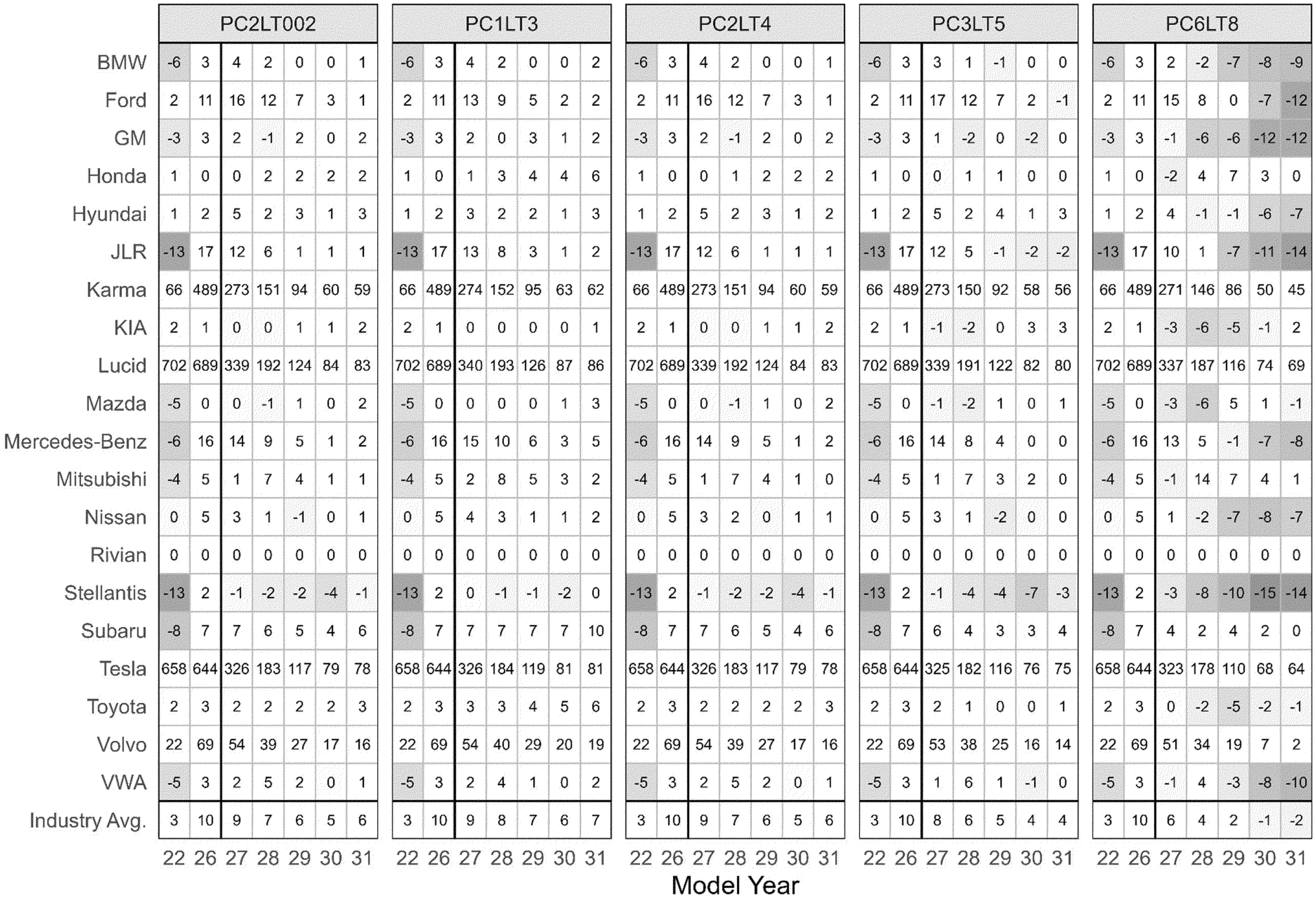
Figure VI-19: Achieved Fuel Economy in MPG Relative to Required Levels under Regulatory Alternatives, Passenger Cars



PC2LT002

	22	26	27	28	29	30	31
BMW	-6	3	4	2	0	0	1
Ford	2	11	16	12	7	3	1
GM	-3	3	2	-1	2	0	2
Honda	1	0	0	2	2	2	2
Hyundai	1	2	5	2	3	1	3
JLR	-13	17	12	6	1	1	1
Karma	66	489	273	151	94	60	59
KIA	2	1	0	0	1	1	2
Lucid	702	689	339	192	124	84	83
Mazda	-5	0	0	-1	1	0	2
Mercedes-Benz	-6	16	14	9	5	1	2
Mitsubishi	-4	5	1	7	4	1	1
Nissan	0	5	3	1	-1	0	1
Rivian	0	0	0	0	0	0	0
Stellantis	-13	2	-1	-2	-2	-4	-1
Subaru	-8	7	7	6	5	4	6
Tesla	658	644	326	183	117	79	78
Toyota	2	3	2	2	2	2	3
Volvo	22	69	54	39	27	17	16
VWA	-5	3	2	5	2	0	1
Industry Avg.	3	10	9	7	6	5	6

PC1LT3

	22	26	27	28	29	30	31
BMW	-6	3	4	2	0	0	2
Ford	2	11	13	9	5	2	2
GM	-3	3	2	0	3	1	2
Honda	1	0	1	3	4	4	6
Hyundai	1	2	3	2	2	1	3
JLR	-13	17	13	8	3	1	2
Karma	66	489	274	152	95	63	62
KIA	2	1	0	0	0	0	1
Lucid	702	689	340	193	126	87	86
Mazda	-5	0	0	0	0	1	3
Mercedes-Benz	-6	16	15	10	6	3	5
Mitsubishi	-4	5	2	8	5	3	2
Nissan	0	5	4	3	1	1	2
Rivian	0	0	0	0	0	0	0
Stellantis	-13	2	0	-1	-1	-2	0
Subaru	-8	7	7	7	7	7	10
Tesla	658	644	326	184	119	81	81
Toyota	2	3	3	3	4	5	6
Volvo	22	69	54	40	29	20	19
VWA	-5	3	2	4	1	0	2
Industry Avg.	3	10	9	8	7	6	7

PC2LT4

	22	26	27	28	29	30	31
BMW	-6	3	4	2	0	0	1
Ford	2	11	16	12	7	3	1
GM	-3	3	2	-1	2	0	2
Honda	1	0	0	1	2	2	2
Hyundai	1	2	5	2	3	1	2
JLR	-13	17	12	6	1	1	1
Karma	66	489	273	151	94	60	59
KIA	2	1	0	0	1	1	2
Lucid	702	689	339	192	124	84	83
Mazda	-5	0	0	-1	1	0	2
Mercedes-Benz	-6	16	14	9	5	1	2
Mitsubishi	-4	5	1	7	4	1	0
Nissan	0	5	3	2	0	1	1
Rivian	0	0	0	0	0	0	0
Stellantis	-13	2	-1	-2	-2	-4	-1
Subaru	-8	7	7	6	5	4	6
Tesla	658	644	326	183	117	79	78
Toyota	2	3	2	2	2	2	3
Volvo	22	69	54	39	27	17	16
VWA	-5	3	2	5	2	0	1
Industry Avg.	3	10	9	7	6	5	6

PC3LT5

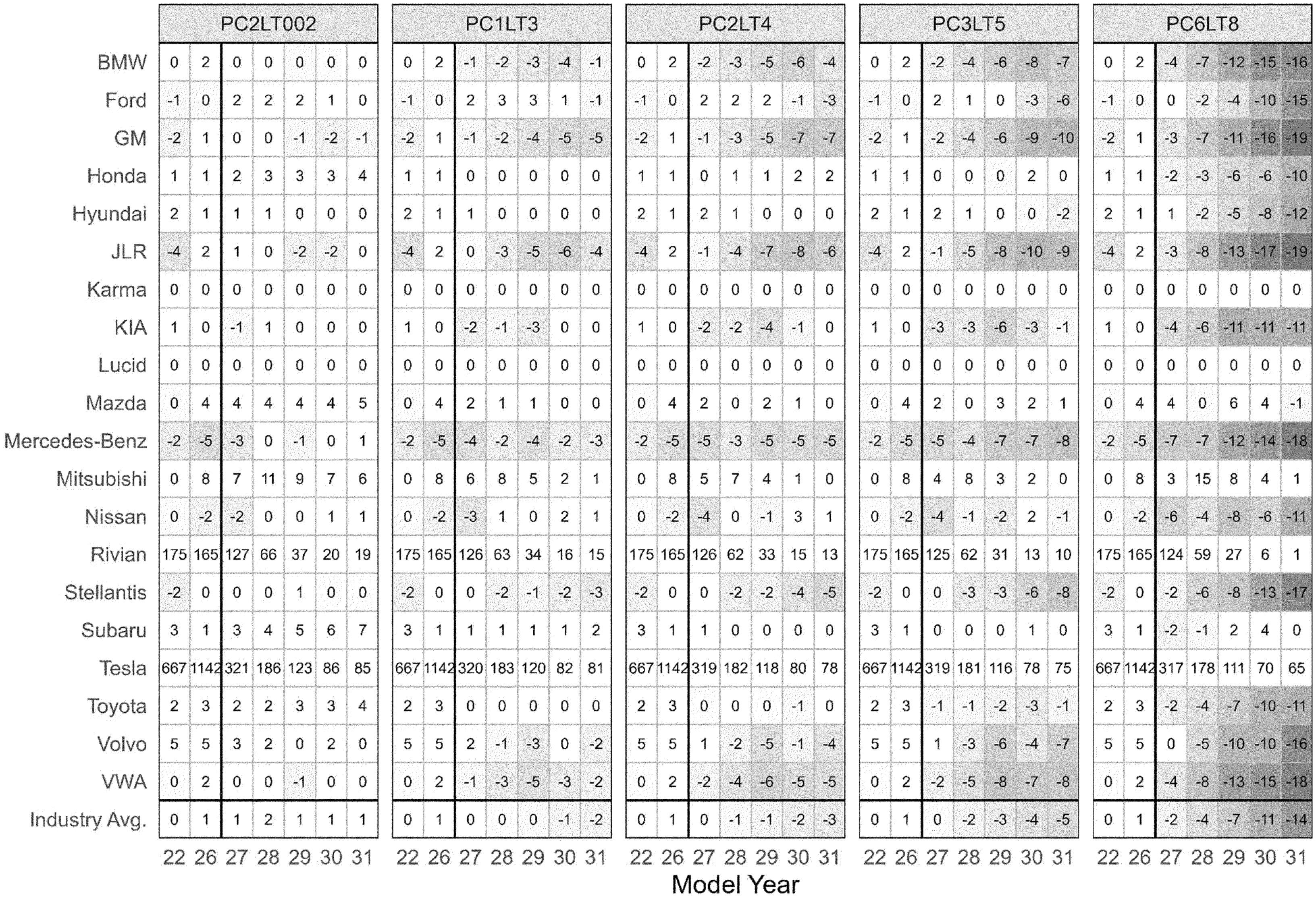
	22	26	27	28	29	30	31
BMW	-6	3	3	1	-1	0	0
Ford	2	11	17	12	7	2	-1
GM	-3	3	1	-2	0	-2	0
Honda	1	0	0	1	1	0	0
Hyundai	1	2	5	2	4	1	3
JLR	-13	17	12	5	-1	-2	-2
Karma	66	489	273	150	92	58	56
KIA	2	1	-1	-2	0	3	3
Lucid	702	689	339	191	122	82	80
Mazda	-5	0	-1	-2	1	0	1
Mercedes-Benz	-6	16	14	8	4	0	0
Mitsubishi	-4	5	1	7	3	2	0
Nissan	0	5	3	1	-2	0	0
Rivian	0	0	0	0	0	0	0
Stellantis	-13	2	-1	-4	-4	-7	-3
Subaru	-8	7	6	4	3	3	4
Tesla	658	644	325	182	116	76	75
Toyota	2	3	2	1	0	0	1
Volvo	22	69	53	38	25	16	14
VWA	-5	3	1	6	1	-1	0
Industry Avg.	3	10	8	6	5	4	4

PC6LT8

	22	26	27	28	29	30	31
BMW	-6	3	2	-2	-7	-8	-9
Ford	2	11	15	8	0	-7	-12
GM	-3	3	-1	-6	-6	-12	-12
Honda	1	0	-2	4	7	3	0
Hyundai	1	2	4	-1	-1	-6	-7
JLR	-13	17	10	1	-7	-11	-14
Karma	66	489	271	146	86	50	45
KIA	2	1	-3	-6	-5	-1	2
Lucid	702	689	337	187	116	74	69
Mazda	-5	0	-3	-6	5	1	-1
Mercedes-Benz	-6	16	13	5	-1	-7	-8
Mitsubishi	-4	5	-1	14	7	4	1
Nissan	0	5	1	-2	-7	-8	-7
Rivian	0	0	0	0	0	0	0
Stellantis	-13	2	-3	-8	-10	-15	-14
Subaru	-8	7	4	2	4	2	0
Tesla	658	644	323	178	110	68	64
Toyota	2	3	0	-2	-5	-2	-1
Volvo	22	69	51	34	19	7	2
VWA	-5	3	-1	4	-3	-8	-10
Industry Avg.	3	10	6	4	2	-1	-2

Model Year

Figure VI-20: Achieved Fuel Economy in MPG Relative to Required Levels under Regulatory Alternatives, Light Trucks



PC2LT002	22	26	27	28	29	30	31
BMW	0	2	0	0	0	0	0
Ford	-1	0	2	2	2	1	0
GM	-2	1	0	0	-1	-2	-1
Honda	1	1	2	3	3	3	4
Hyundai	2	1	1	1	0	0	0
JLR	-4	2	1	0	-2	-2	0
Karma	0	0	0	0	0	0	0
KIA	1	0	-1	1	0	0	0
Lucid	0	0	0	0	0	0	0
Mazda	0	4	4	4	4	4	5
Mercedes-Benz	-2	-5	-3	0	-1	0	1
Mitsubishi	0	8	7	11	9	7	6
Nissan	0	-2	-2	0	0	1	1
Rivian	175	165	127	66	37	20	19
Stellantis	-2	0	0	0	1	0	0
Subaru	3	1	3	4	5	6	7
Tesla	667	1142	321	186	123	86	85
Toyota	2	3	2	2	3	3	4
Volvo	5	5	3	2	0	2	0
VWA	0	2	0	0	-1	0	0
Industry Avg.	0	1	1	2	1	1	1

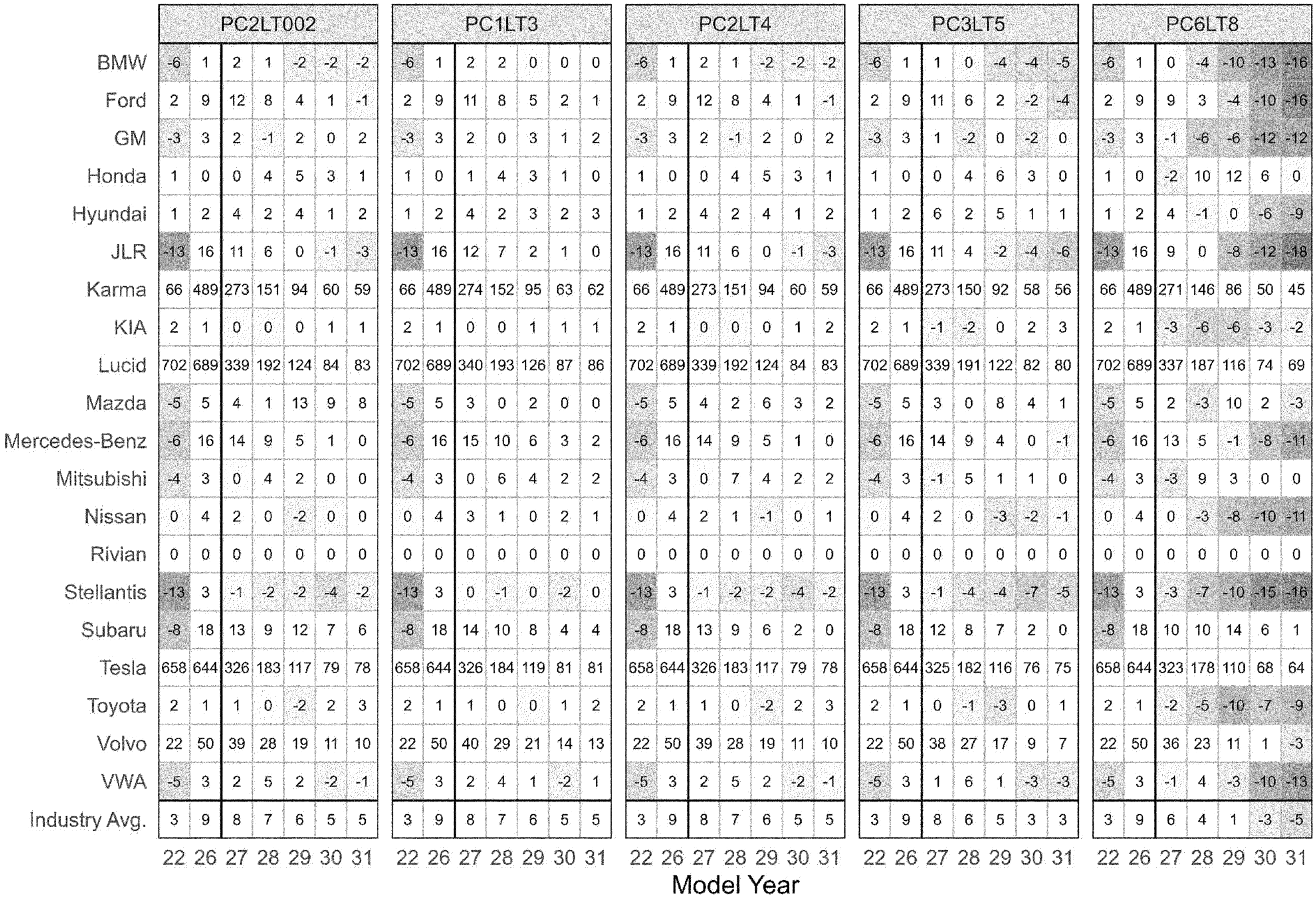
PC1LT3	22	26	27	28	29	30	31
BMW	0	2	-1	-2	-3	-4	-1
Ford	-1	0	2	3	3	1	-1
GM	-2	1	-1	-2	-4	-5	-5
Honda	1	1	0	0	0	0	0
Hyundai	2	1	1	0	0	0	0
JLR	-4	2	0	-3	-5	-6	-4
Karma	0	0	0	0	0	0	0
KIA	1	0	-2	-1	-3	0	0
Lucid	0	0	0	0	0	0	0
Mazda	0	4	2	1	1	0	0
Mercedes-Benz	-2	-5	-4	-2	-4	-2	-3
Mitsubishi	0	8	6	8	5	2	1
Nissan	0	-2	-3	1	0	2	1
Rivian	175	165	126	63	34	16	15
Stellantis	-2	0	0	-2	-1	-2	-3
Subaru	3	1	1	1	1	1	2
Tesla	667	1142	320	183	120	82	81
Toyota	2	3	0	0	0	0	0
Volvo	5	5	2	-1	-3	0	-2
VWA	0	2	-1	-3	-5	-3	-2
Industry Avg.	0	1	0	0	0	-1	-2

PC2LT4	22	26	27	28	29	30	31
BMW	0	2	-2	-3	-5	-6	-4
Ford	-1	0	2	2	2	-1	-3
GM	-2	1	-1	-3	-5	-7	-7
Honda	1	1	0	1	1	2	2
Hyundai	2	1	2	1	0	0	0
JLR	-4	2	-1	-4	-7	-8	-6
Karma	0	0	0	0	0	0	0
KIA	1	0	-2	-2	-4	-1	0
Lucid	0	0	0	0	0	0	0
Mazda	0	4	2	0	2	1	0
Mercedes-Benz	-2	-5	-5	-3	-5	-5	-5
Mitsubishi	0	8	5	7	4	1	0
Nissan	0	-2	-4	0	-1	3	1
Rivian	175	165	126	62	33	15	13
Stellantis	-2	0	0	-2	-2	-4	-5
Subaru	3	1	1	0	0	0	0
Tesla	667	1142	319	182	118	80	78
Toyota	2	3	0	0	0	-1	0
Volvo	5	5	1	-2	-5	-1	-4
VWA	0	2	-2	-4	-6	-5	-5
Industry Avg.	0	1	0	-1	-1	-2	-3

PC3LT5	22	26	27	28	29	30	31
BMW	0	2	-2	-4	-6	-8	-7
Ford	-1	0	2	1	0	-3	-6
GM	-2	1	-2	-4	-6	-9	-10
Honda	1	1	0	0	0	2	0
Hyundai	2	1	2	1	0	0	-2
JLR	-4	2	-1	-5	-8	-10	-9
Karma	0	0	0	0	0	0	0
KIA	1	0	-3	-3	-6	-3	-1
Lucid	0	0	0	0	0	0	0
Mazda	0	4	2	0	3	2	1
Mercedes-Benz	-2	-5	-5	-4	-7	-7	-8
Mitsubishi	0	8	4	8	3	2	0
Nissan	0	-2	-4	-1	-2	2	-1
Rivian	175	165	125	62	31	13	10
Stellantis	-2	0	0	-3	-3	-6	-8
Subaru	3	1	0	0	0	1	0
Tesla	667	1142	319	181	116	78	75
Toyota	2	3	-1	-1	-2	-3	-1
Volvo	5	5	1	-3	-6	-4	-7
VWA	0	2	-2	-5	-8	-7	-8
Industry Avg.	0	1	0	-2	-3	-4	-5

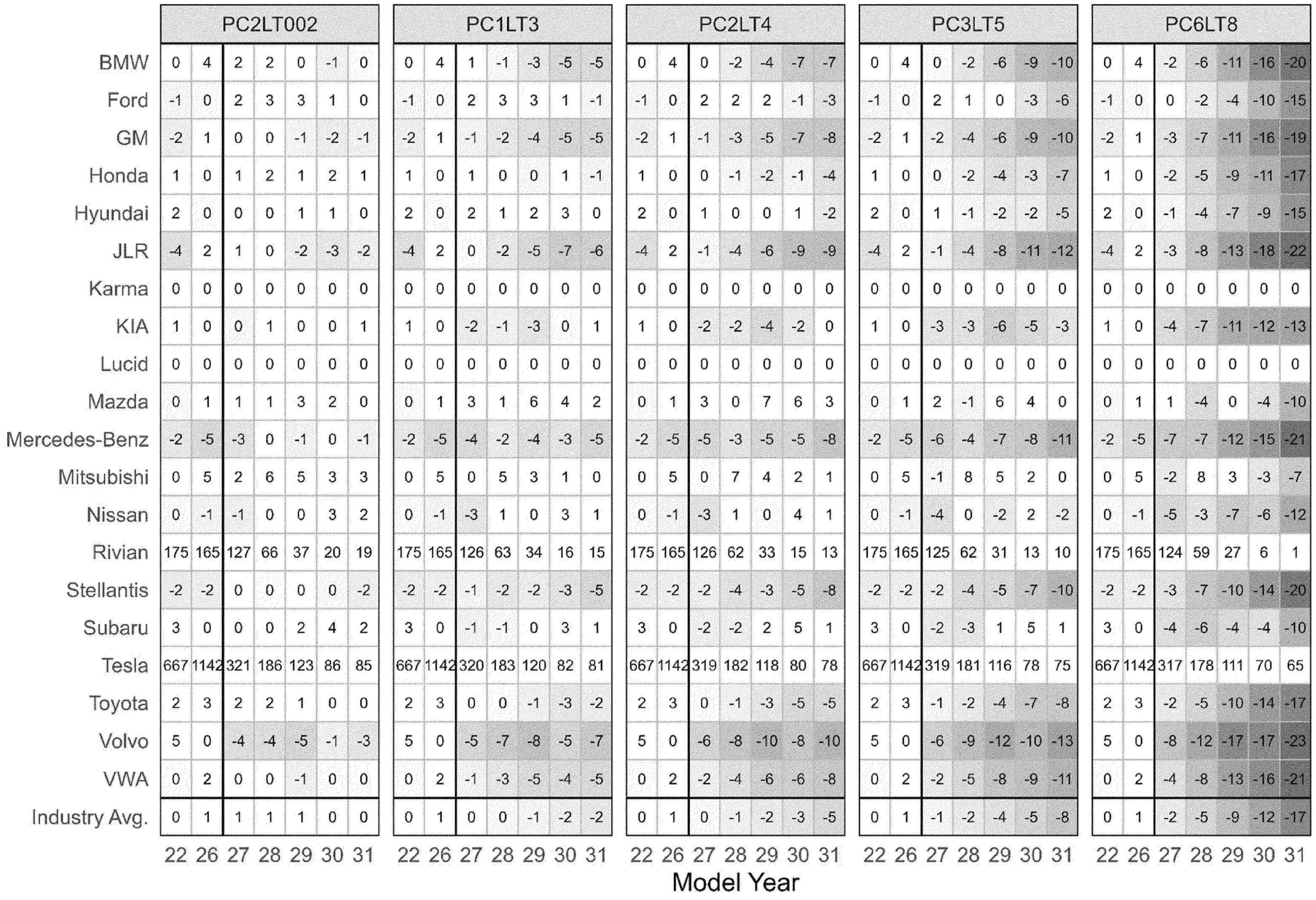
PC6LT8	22	26	27	28	29	30	31
BMW	0	2	-4	-7	-12	-15	-16
Ford	-1	0	0	-2	-4	-10	-15
GM	-2	1	-3	-7	-11	-16	-19
Honda	1	1	-2	-3	-6	-6	-10
Hyundai	2	1	1	-2	-5	-8	-12
JLR	-4	2	-3	-8	-13	-17	-19
Karma	0	0	0	0	0	0	0
KIA	1	0	-4	-6	-11	-11	-11
Lucid	0	0	0	0	0	0	0
Mazda	0	4	4	0	6	4	-1
Mercedes-Benz	-2	-5	-7	-7	-12	-14	-18
Mitsubishi	0	8	3	15	8	4	1
Nissan	0	-2	-6	-4	-8	-6	-11
Rivian	175	165	124	59	27	6	1
Stellantis	-2	0	-2	-6	-8	-13	-17
Subaru	3	1	-2	-1	2	4	0
Tesla	667	1142	317	178	111	70	65
Toyota	2	3	-2	-4	-7	-10	-11
Volvo	5	5	0	-5	-10	-10	-16
VWA	0	2	-4	-8	-13	-15	-18
Industry Avg.	0	1	-2	-4	-7	-11	-14

Figure VI-21: Achieved Fuel Economy in MPG Relative to Required Levels under No ZEV Alternative Baseline, Passenger Cars



	PC2LT002							PC1LT3							PC2LT4							PC3LT5							PC6LT8						
Model Year	22	26	27	28	29	30	31	22	26	27	28	29	30	31	22	26	27	28	29	30	31	22	26	27	28	29	30	31	22	26	27	28	29	30	31
BMW	-6	1	2	1	-2	-2	-2	-6	1	2	2	0	0	0	-6	1	2	1	-2	-2	-2	-6	1	1	0	-4	-4	-5	-6	1	0	-4	-10	-13	-16
Ford	2	9	12	8	4	1	-1	2	9	11	8	5	2	1	2	9	12	8	4	1	-1	2	9	11	6	2	-2	-4	2	9	9	3	-4	-10	-16
GM	-3	3	2	-1	2	0	2	-3	3	2	0	3	1	2	-3	3	2	-1	2	0	2	-3	3	1	-2	0	-2	0	-3	3	-1	-6	-6	-12	-12
Honda	1	0	0	4	5	3	1	1	0	1	4	3	1	0	1	0	0	4	5	3	1	1	0	0	4	6	3	0	1	0	-2	10	12	6	0
Hyundai	1	2	4	2	4	1	2	1	2	4	2	3	2	3	1	2	4	2	4	1	2	1	2	6	2	5	1	1	1	2	4	-1	0	-6	-9
JLR	-13	16	11	6	0	-1	-3	-13	16	12	7	2	1	0	-13	16	11	6	0	-1	-3	-13	16	11	4	-2	-4	-6	-13	16	9	0	-8	-12	-18
Karma	66	489	273	151	94	60	59	66	489	274	152	95	63	62	66	489	273	151	94	60	59	66	489	273	150	92	58	56	66	489	271	146	86	50	45
KIA	2	1	0	0	0	1	1	2	1	0	0	1	1	1	2	1	0	0	0	1	2	2	1	-1	-2	0	2	3	2	1	-3	-6	-6	-3	-2
Lucid	702	689	339	192	124	84	83	702	689	340	193	126	87	86	702	689	339	192	124	84	83	702	689	339	191	122	82	80	702	689	337	187	116	74	69
Mazda	-5	5	4	1	13	9	8	-5	5	3	0	2	0	0	-5	5	4	2	6	3	2	-5	5	3	0	8	4	1	-5	5	2	-3	10	2	-3
Mercedes-Benz	-6	16	14	9	5	1	0	-6	16	15	10	6	3	2	-6	16	14	9	5	1	0	-6	16	14	9	4	0	-1	-6	16	13	5	-1	-8	-11
Mitsubishi	-4	3	0	4	2	0	0	-4	3	0	6	4	2	2	-4	3	0	7	4	2	2	-4	3	-1	5	1	1	0	-4	3	-3	9	3	0	0
Nissan	0	4	2	0	-2	0	0	0	4	3	1	0	2	1	0	4	2	1	-1	0	1	0	4	2	0	-3	-2	-1	0	4	0	-3	-8	-10	-11
Rivian	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stellantis	-13	3	-1	-2	-2	-4	-2	-13	3	0	-1	0	-2	0	-13	3	-1	-2	-2	-4	-2	-13	3	-1	-4	-4	-7	-5	-13	3	-3	-7	-10	-15	-16
Subaru	-8	18	13	9	12	7	6	-8	18	14	10	8	4	4	-8	18	13	9	6	2	0	-8	18	12	8	7	2	0	-8	18	10	10	14	6	1
Tesla	658	644	326	183	117	79	78	658	644	326	184	119	81	81	658	644	326	183	117	79	78	658	644	325	182	116	76	75	658	644	323	178	110	68	64
Toyota	2	1	1	0	-2	2	3	2	1	1	0	0	1	2	2	1	1	0	-2	2	3	2	1	0	-1	-3	0	1	2	1	-2	-5	-10	-7	-9
Volvo	22	50	39	28	19	11	10	22	50	40	29	21	14	13	22	50	39	28	19	11	10	22	50	38	27	17	9	7	22	50	36	23	11	1	-3
VWA	-5	3	2	5	2	-2	-1	-5	3	2	4	1	-2	1	-5	3	2	5	2	-2	-1	-5	3	1	6	1	-3	-3	-5	3	-1	4	-3	-10	-13
Industry Avg.	3	9	8	7	6	5	5	3	9	8	7	6	5	5	3	9	8	7	6	5	5	3	9	8	6	5	3	3	3	9	6	4	1	-3	-5

Figure VI-22: Achieved Fuel Economy in MPG Relative to Required Levels under No ZEV Alternative Baseline, Light Trucks



	PC2LT002						
	22	26	27	28	29	30	31
BMW	0	4	2	2	0	-1	0
Ford	-1	0	2	3	3	1	0
GM	-2	1	0	0	-1	-2	-1
Honda	1	0	1	2	1	2	1
Hyundai	2	0	0	0	1	1	0
JLR	-4	2	1	0	-2	-3	-2
Karma	0	0	0	0	0	0	0
KIA	1	0	0	1	0	0	1
Lucid	0	0	0	0	0	0	0
Mazda	0	1	1	1	3	2	0
Mercedes-Benz	-2	-5	-3	0	-1	0	-1
Mitsubishi	0	5	2	6	5	3	3
Nissan	0	-1	-1	0	0	3	2
Rivian	175	165	127	66	37	20	19
Stellantis	-2	-2	0	0	0	0	-2
Subaru	3	0	0	0	2	4	2
Tesla	667	1142	321	186	123	86	85
Toyota	2	3	2	2	1	0	0
Volvo	5	0	-4	-4	-5	-1	-3
VWA	0	2	0	0	-1	0	0
Industry Avg.	0	1	1	1	1	0	0

	PC1LT3						
	22	26	27	28	29	30	31
BMW	0	4	1	-1	-3	-5	-5
Ford	-1	0	2	3	3	1	-1
GM	-2	1	-1	-2	-4	-5	-5
Honda	1	0	1	0	0	1	-1
Hyundai	2	0	2	1	2	3	0
JLR	-4	2	0	-2	-5	-7	-6
Karma	0	0	0	0	0	0	0
KIA	1	0	-2	-1	-3	0	1
Lucid	0	0	0	0	0	0	0
Mazda	0	1	3	1	6	4	2
Mercedes-Benz	-2	-5	-4	-2	-4	-3	-5
Mitsubishi	0	5	0	5	3	1	0
Nissan	0	-1	-3	1	0	3	1
Rivian	175	165	126	63	34	16	15
Stellantis	-2	-2	-1	-2	-2	-3	-5
Subaru	3	0	-1	-1	0	3	1
Tesla	667	1142	320	183	120	82	81
Toyota	2	3	0	0	-1	-3	-2
Volvo	5	0	-5	-7	-8	-5	-7
VWA	0	2	-1	-3	-5	-4	-5
Industry Avg.	0	1	0	0	-1	-2	-2

	PC2LT4						
	22	26	27	28	29	30	31
BMW	0	4	0	-2	-4	-7	-7
Ford	-1	0	2	2	2	-1	-3
GM	-2	1	-1	-3	-5	-7	-8
Honda	1	0	0	-1	-2	-1	-4
Hyundai	2	0	1	0	0	1	-2
JLR	-4	2	-1	-4	-6	-9	-9
Karma	0	0	0	0	0	0	0
KIA	1	0	-2	-2	-4	-2	0
Lucid	0	0	0	0	0	0	0
Mazda	0	1	3	0	7	6	3
Mercedes-Benz	-2	-5	-5	-3	-5	-5	-8
Mitsubishi	0	5	0	7	4	2	1
Nissan	0	-1	-3	1	0	4	1
Rivian	175	165	126	62	33	15	13
Stellantis	-2	-2	-2	-4	-3	-5	-8
Subaru	3	0	-2	-2	2	5	1
Tesla	667	1142	319	182	118	80	78
Toyota	2	3	0	-1	-3	-5	-5
Volvo	5	0	-6	-8	-10	-8	-10
VWA	0	2	-2	-4	-6	-6	-8
Industry Avg.	0	1	0	-1	-2	-3	-5

	PC3LT5						
	22	26	27	28	29	30	31
BMW	0	4	0	-2	-6	-9	-10
Ford	-1	0	2	1	0	-3	-6
GM	-2	1	-2	-4	-6	-9	-10
Honda	1	0	0	-2	-4	-3	-7
Hyundai	2	0	1	-1	-2	-2	-5
JLR	-4	2	-1	-4	-8	-11	-12
Karma	0	0	0	0	0	0	0
KIA	1	0	-3	-3	-6	-5	-3
Lucid	0	0	0	0	0	0	0
Mazda	0	1	2	-1	6	4	0
Mercedes-Benz	-2	-5	-6	-4	-7	-8	-11
Mitsubishi	0	5	-1	8	5	2	0
Nissan	0	-1	-4	0	-2	2	-2
Rivian	175	165	125	62	31	13	10
Stellantis	-2	-2	-2	-4	-5	-7	-10
Subaru	3	0	-2	-3	1	5	1
Tesla	667	1142	319	181	116	78	75
Toyota	2	3	-1	-2	-4	-7	-8
Volvo	5	0	-6	-9	-12	-10	-13
VWA	0	2	-2	-5	-8	-9	-11
Industry Avg.	0	1	-1	-2	-4	-5	-8

	PC6LT8						
	22	26	27	28	29	30	31
BMW	0	4	-2	-6	-11	-16	-20
Ford	-1	0	0	-2	-4	-10	-15
GM	-2	1	-3	-7	-11	-16	-19
Honda	1	0	-2	-5	-9	-11	-17
Hyundai	2	0	-1	-4	-7	-9	-15
JLR	-4	2	-3	-8	-13	-18	-22
Karma	0	0	0	0	0	0	0
KIA	1	0	-4	-7	-11	-12	-13
Lucid	0	0	0	0	0	0	0
Mazda	0	1	1	-4	0	-4	-10
Mercedes-Benz	-2	-5	-7	-7	-12	-15	-21
Mitsubishi	0	5	-2	8	3	-3	-7
Nissan	0	-1	-5	-3	-7	-6	-12
Rivian	175	165	124	59	27	6	1
Stellantis	-2	-2	-3	-7	-10	-14	-20
Subaru	3	0	-4	-6	-4	-4	-10
Tesla	667	1142	317	178	111	70	65
Toyota	2	3	-2	-5	-10	-14	-17
Volvo	5	0	-8	-12	-17	-17	-23
VWA	0	2	-4	-8	-13	-16	-21
Industry Avg.	0	1	-2	-5	-9	-12	-17

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Under both the reference baseline and the No ZEV alternative baseline analyses, for passenger cars, the industry average again obscures more serious shortfall trends among individual manufacturers, with results slightly intensified for some manufacturers under the No ZEV alternative baseline analysis. Many manufacturers' passenger car fleets are estimated to fall significantly short of required levels under PC6LT8, with only one non-BEV manufacturer achieving compliance for most of the model years covered by the rulemaking. Even for PC3LT5, a large part of the sales volume of non-BEV-only manufacturers still appears to be falling short in most model years. Passenger car shortfalls are much less widespread under PC2LT4 and PC2LT002. For light trucks, under both the reference baseline and the No ZEV alternative baseline analyses, the shortfalls are extensive under PC6LT8, and most of non-BEV-only manufacturers fall short in most if not all model years under PC3LT5. Even PC2LT4 and PC1LT3 appears challenging, if not simply unattainable, under the standard-setting runs for a large portion of the light truck sales volume of non-BEV-only manufacturers. Given all of the data examined, and the unique circumstances of this rulemaking discussed above, NHTSA believes that PC2LT002 may represent the upper limit of economic practicability during the rulemaking time frame.

Of course, CAFE standards are performance-based, and NHTSA does not dictate specific technology paths for meeting them, so it is entirely possible that individual manufacturers and industry as a whole will take a different path from the one that NHTSA presents here.[1442] Nonetheless, this is *a* path toward compliance, relying on known, existing technology, and NHTSA believes that our analysis suggests that the levels of technology and cost required by PC2LT002 are reasonable and economically practicable in the rulemaking time frame.

The tables and discussion also illustrate that, for purposes of this final rule, economic practicability points in the opposite direction of the need of the U.S. to conserve energy. It is within NHTSA's discretion to forgo the potential prospect of additional energy conservation benefits if NHTSA believes that more stringent standards would be economically impracticable, and thus, beyond maximum feasible.

Changes in costs for new vehicles are not the only costs that NHTSA considers in balancing the statutory factors. Fuel costs for consumers are relevant to the need of the U.S. to conserve energy, and NHTSA believes that consumers themselves weigh expected fuel savings against increases in purchase price for vehicles with higher fuel economy, although the extent to which consumers value fuel economy improvements is hotly debated, as discussed in Chapter 2.1.4 of the TSD. Fuel costs (or savings) continue, for now, to be the largest source of benefits for CAFE standards. Comparing private costs to private benefits, the estimated results for American consumers are as follows:

Table VI-30: Incremental Private Benefits and Private Costs Over the Lifetimes of Total Passenger Car Fleet Produced Through MY 2031 (2021$ Billions), 3 Percent Discount Rate, by Alternative

Alternative	PC2LT002	PC1LT3	PC2LT4	PC3LT5	PC6LT8
Private Costs					
Technology Costs to Increase Fuel Economy	5.5	1.5	4.5	7.4	13.5
Increased Maintenance and Repair Costs	0.0	0.0	0.0	0.0	0.0
Opportunity Cost in Other Vehicle Attributes	0.0	0.0	0.0	0.0	0.0
Consumer Surplus Loss from Reduced New Vehicle Sales	0.0	0.0	0.0	0.1	0.2
Safety Costs Internalized by Drivers	1.0	0.8	1.2	1.6	2.6
Subtotal – Incremental Private Costs	6.5	2.3	5.8	9.1	16.4
Private Benefits					
Reduced Fuel Costs	8.0	2.4	4.3	6.0	10.9
Benefits from Additional Driving	1.6	1.2	1.8	2.4	3.9
Less Frequent Refueling	0.6	0.0	0.2	0.3	0.7
Subtotal – Incremental Private Benefits	10.1	3.7	6.3	8.7	15.5
Net Incremental Private Benefits	3.6	1.4	0.6	-0.3	-0.8

[1442] NHTSA acknowledges that compliance looks easier and more cost-effective for many manufacturers under the "unconstrained" analysis as compared to the "standard-setting" analysis discussed here, but emphasizes that NHTSA's decision on maximum feasible standards must be based on the standard-setting analysis reflecting the 32902(h) restrictions.

Table VI-31: Incremental Private Benefits and Private Costs Over the Lifetimes of Total Light Truck Fleet Produced Through MY 2031 (2021$ Billions), 3 Percent Discount Rate, by Alternative

Alternative	PC2LT002	PC1LT3	PC2LT4	PC3LT5	PC6LT8
Private Costs					
Technology Costs to Increase Fuel Economy	8.5	15.4	21.1	24.7	29.6
Increased Maintenance and Repair Costs	0.0	0.0	0.0	0.0	0.0
Opportunity Cost in Other Vehicle Attributes	0.0	0.0	0.0	0.0	0.0
Consumer Surplus Loss from Reduced New Vehicle Sales	0.0	0.0	0.0	0.1	0.5
Safety Costs Internalized by Drivers	1.7	3.5	4.4	4.9	5.3
Subtotal – Incremental Private Costs	10.2	19.0	25.6	29.7	35.4
Private Benefits					
Reduced Fuel Costs	13.4	29.9	36.4	38.8	41.0
Benefits from Additional Driving	2.8	5.7	7.2	7.9	8.5
Less Frequent Refueling	0.8	1.7	2.0	2.2	2.4
Subtotal – Incremental Private Benefits	16.9	37.3	45.6	48.8	52.0
Net Incremental Private Benefits	6.7	18.3	20.0	19.2	16.6

Looking simply at the effects for consumers, our analysis suggests that private benefits would outweigh private costs for passenger cars under PC2LT002, PC1LT3, and PC2LT4, with PC2LT002 being the most beneficial for passenger car purchasers. For light trucks, all of the action alternatives appear net beneficial for consumers, with PC2LT4 and PC3LT5 being the most beneficial. Under the No ZEV alternative baseline analysis, comparing private costs to private benefits, the estimated results for American consumers are as follows:

Table VI-32: Incremental Private Benefits and Private Costs Over the Lifetimes of Total Passenger Car Fleet Produced Through MY 2031 (2021$ Billions), 3 Percent Discount Rate, by Alternative, No ZEV Alternative Baseline Analysis

Alternative	PC2LT002	PC1LT3	PC2LT4	PC3LT5	PC6LT8
Private Costs					
Technology Costs to Increase Fuel Economy	5.8	1.9	5.9	8.5	15.0
Increased Maintenance and Repair Costs	0.0	0.0	0.0	0.0	0.0
Opportunity Cost in Other Vehicle Attributes	0.0	0.0	0.0	0.0	0.0
Consumer Surplus Loss from Reduced New Vehicle Sales	0.0	0.0	0.1	0.1	0.4
Safety Costs Internalized by Drivers	1.8	1.3	2.0	2.4	3.1
Subtotal – Incremental Private Costs	7.6	3.3	7.9	11.0	18.4
Private Benefits					
Reduced Fuel Costs	10.3	2.0	6.2	7.8	11.6
Benefits from Additional Driving	2.6	2.0	2.9	3.5	4.4
Less Frequent Refueling	0.6	-0.1	0.2	0.3	0.7
Subtotal – Incremental Private Benefits	13.5	3.9	9.3	11.6	16.8
Net Incremental Private Benefits	5.9	0.6	1.4	0.6	-1.7

Table VI-33: Incremental Private Benefits and Private Costs Over the Lifetimes of Total Light Truck Fleet Produced Through MY 2031 (2021$ Billions), 3 Percent Discount Rate, by Alternative, No ZEV Alternative Baseline Analysis

Alternative	PC2LT002	PC1LT3	PC2LT4	PC3LT5	PC6LT8
Private Costs					
Technology Costs to Increase Fuel Economy	12.0	25.7	27.8	31.5	31.3
Increased Maintenance and Repair Costs	0.0	0.0	0.0	0.0	0.0
Opportunity Cost in Other Vehicle Attributes	0.0	0.0	0.0	0.0	0.0
Consumer Surplus Loss from Reduced New Vehicle Sales	0.0	0.1	0.1	0.2	0.7
Safety Costs Internalized by Drivers	2.6	4.7	5.0	5.1	5.0
Subtotal – Incremental Private Costs	14.7	30.5	32.9	36.8	37.0
Private Benefits					
Reduced Fuel Costs	19.5	40.2	41.5	41.7	39.1
Benefits from Additional Driving	4.3	7.5	8.0	8.0	8.0
Less Frequent Refueling	1.1	2.2	2.3	2.4	2.3
Subtotal – Incremental Private Benefits	24.9	49.9	51.9	52.1	49.4
Net Incremental Private Benefits	10.2	19.4	18.9	15.3	12.4

Again, looking simply at the effects for consumers, our analysis suggests that private benefits would outweigh private costs for passenger cars under PC2LT002, PC1LT3, PC2LT4, and PC3LT5, with PC2LT002 being by far the most beneficial for passenger car purchasers. For light trucks, all of the action alternatives appear net beneficial for consumers, with PC1LT3 being the most beneficial.

Broadening the scope to consider external/governmental benefits as well, we see the following:

Table VI-34: Incremental Benefits and Costs Over the Lifetimes of Total Passenger Car Fleet Produced Through MY 2031 (2021$ Billions), 3 Percent Social Discount Rate, by Alternative, 2% SC-GHG Discount Rate

Alternative	PC2LT002	PC1LT3	PC2LT4	PC3LT5	PC6LT8
Private Costs (see Table VI-30 above)					
Subtotal – Incremental Private Costs	6.5	2.3	5.8	9.1	16.4
External Costs					
Congestion and Noise Costs from Rebound-Effect Driving	0.1	3.5	4.7	5.7	6.9
Safety Costs Not Internalized by Drivers	-0.7	5.6	7.4	9.2	11.1
Loss in Fuel Tax Revenue	1.4	0.4	0.7	1.0	1.7
Subtotal – Incremental External Costs	0.7	9.5	12.9	15.9	19.7
Total Incremental Social Costs	7.2	11.9	18.6	25.0	36.0
Private Benefits (see Table VI-30 above)					
Subtotal – Incremental Private Benefits	10.1	3.7	6.3	8.7	15.5
External Benefits					
Reduction in Petroleum Market Externality	0.3	0.1	0.2	0.2	0.4
Reduced Climate Damages, 2.0% SC-GHG DR	10.2	3.2	5.5	7.5	13.5
Reduced Health Damages	0.2	-0.1	-0.2	-0.2	-0.3
Subtotal – Incremental External Benefits	10.8	3.1	5.5	7.5	13.6
Total Incremental Social Benefits, 2.0% SC-GHG DR	20.9	6.8	11.8	16.3	29.1
Net Incremental Social Benefits, 2.0% SC-GHG DR	13.7	-5.0	-6.8	-8.7	-6.9

Table VI-35: Incremental Benefits and Costs Over the Lifetimes of Total Light Truck Fleet Produced Through MY 2031 (2021$ Billions), 3 Percent Social Discount Rate, by Alternative, 2% SC-GHG Discount Rate

Alternative	PC2LT002	PC1LT3	PC2LT4	PC3LT5	PC6LT8
Private Costs (see Table VI-15 above)					
Subtotal – Incremental Private Costs	10.2	19.0	25.6	29.7	35.4
External Costs					
Congestion and Noise Costs from Rebound-Effect Driving	2.0	-0.5	0.0	0.8	1.5
Safety Costs Not Internalized by Drivers	2.1	-3.8	-3.4	-2.0	0.9
Loss in Fuel Tax Revenue	2.9	5.3	6.3	6.7	7.0
Subtotal – Incremental External Costs	7.0	1.0	2.9	5.5	9.4
Total Incremental Social Costs	17.3	19.9	28.5	35.1	44.7
Private Benefits (see Table VI-15 above)					
Subtotal – Incremental Private Benefits	16.9	37.3	45.6	48.8	52.0
External Benefits					
Reduction in Petroleum Market Externality	0.7	1.3	1.5	1.6	1.7
Reduced Climate Damages, 2.0% SC-GHG DR	20.7	39.5	47.3	50.1	53.0
Reduced Health Damages	0.5	0.9	1.0	0.9	0.9
Subtotal – Incremental External Benefits	21.9	41.7	49.8	52.7	55.5
Total Incremental Social Benefits, 2.0% SC-GHG DR	38.8	79.0	95.4	101.5	107.5
Net Incremental Social Benefits, 2.0% SC-GHG DR	21.5	59.0	66.9	66.4	62.7

Adding external/social costs and benefits does not change the direction of NHTSA's analytical findings. Net benefits for passenger cars become negative across all alternatives except for PC2LT002.[1443] Net benefits for light trucks remain positive across alternatives, with a peak at PC2LT4.

Under the No ZEV alternative baseline analysis, adding external/social costs and benefits still does not change the direction of NHTSA's analytical findings, as the tables illustrate:

[1443] This behavior is discussed in Section VI.A.5.a.(2).

Table VI-36: Incremental Benefits and Costs Over the Lifetimes of Total Passenger Car Fleet Produced Through MY 2031 (2021$ Billions), 3 Percent Social Discount Rate, by Alternative, 2% SC-GHG Discount Rate, No ZEV Alternative Baseline Analysis

Alternative	PC2LT002	PC1LT3	PC2LT4	PC3LT5	PC6LT8
Private Costs (see Table VI-30 above)					
Subtotal – Incremental Private Costs	7.6	3.3	7.9	11.0	18.4
External Costs					
Congestion and Noise Costs from Rebound-Effect Driving	1.0	7.0	6.8	8.1	7.7
Safety Costs Not Internalized by Drivers	0.3	11.5	10.9	12.9	12.8
Loss in Fuel Tax Revenue	1.5	0.2	0.8	1.1	1.6
Subtotal – Incremental External Costs	2.9	18.7	18.6	22.1	22.1
Total Incremental Social Costs	10.5	22.0	26.5	33.1	40.6
Private Benefits (see Table VI-30 above)					
Subtotal – Incremental Private Benefits	13.5	3.9	9.3	11.6	16.8
External Benefits					
Reduction in Petroleum Market Externality	0.4	0.1	0.2	0.3	0.4
Reduced Climate Damages, 2.0% SC-GHG DR	11.8	2.0	7.0	9.0	13.7
Reduced Health Damages	0.0	-0.4	-0.4	-0.5	-0.5
Subtotal – Incremental External Benefits	12.2	1.6	6.8	8.9	13.6
Total Incremental Social Benefits, 2.0% SC-GHG DR	25.7	5.5	16.1	20.5	30.3
Net Incremental Social Benefits, 2.0% SC-GHG DR	15.3	-16.5	-10.4	-12.6	-10.2

Table VI-37: Incremental Benefits and Costs Over the Lifetimes of Total Light Truck Fleet Produced Through MY 2031 (2021$ Billions), 3 Percent Social Discount Rate, by Alternative, 2% SC-GHG Discount Rate, No ZEV Alternative Baseline Analysis

Alternative	PC2LT002	PC1LT3	PC2LT4	PC3LT5	PC6LT8
Private Costs (see Table VI-15 above)					
Subtotal – Incremental Private Costs	14.7	30.5	32.9	36.8	37.0
External Costs					
Congestion and Noise Costs from Rebound-Effect Driving	3.1	-1.1	0.0	0.0	1.6
Safety Costs Not Internalized by Drivers	3.3	-5.8	-3.7	-2.9	2.4
Loss in Fuel Tax Revenue	3.9	7.0	7.2	7.2	6.8
Subtotal – Incremental External Costs	10.2	0.1	3.5	4.3	10.8
Total Incremental Social Costs	24.9	30.6	36.4	41.1	47.8
Private Benefits (see Table VI-15 above)					
Subtotal – Incremental Private Benefits	24.9	49.9	51.9	52.1	49.4
External Benefits					
Reduction in Petroleum Market Externality	0.9	1.7	1.7	1.7	1.7
Reduced Climate Damages, 2.0% SC-GHG DR	28.2	52.5	54.4	54.4	51.5
Reduced Health Damages	0.6	1.2	1.1	1.1	0.9
Subtotal – Incremental External Benefits	29.7	55.4	57.3	57.2	54.0
Total Incremental Social Benefits, 2.0% SC-GHG DR	54.6	105.2	109.1	109.3	103.4
Net Incremental Social Benefits, 2.0% SC-GHG DR	29.7	74.7	72.7	68.2	55.6

Under the No ZEV alternative baseline analysis, net benefits for passenger cars also become negative across all alternatives except for PC2LT002.[1444] Net benefits for light trucks remain positive across alternatives, with a peak at PC1LT3.

Because NHTSA considers multiple discount rates in its analysis, and because analysis also includes multiple values for the SC–GHG, we also estimate the following cumulative values for each regulatory alternative:

[1444] This behavior is discussed in Section VI.A.5.a.(2).

Table VI-38: Summary of Cumulative Benefits and Costs for Model Years through MY 2031 (2021$ Billions), by Alternative, SC-GHG Value, and Discount Rate

Alternative	3% Discount Rate			7% Discount Rate		
	Costs	Benefits	Net Benefits	Costs	Benefits	Net Benefits
SC-GHG discounted at 2.5 percent						
PC2LT002	24.5	47.1	22.7	16.2	34.5	18.2
PC1LT3	31.8	68.5	36.7	21.0	49.4	28.4
PC2LT4	47.1	85.7	38.7	31.0	61.7	30.7
PC3LT5	60.1	94.4	34.3	39.4	67.9	28.5
PC6LT8	80.8	109.6	28.8	53.8	78.4	24.6
SC-GHG discounted at 2 percent						
PC2LT002	24.5	59.7	35.2	16.2	47.0	30.8
PC1LT3	31.8	85.8	54.0	21.0	66.8	45.8
PC2LT4	47.1	107.2	60.1	31.0	83.1	52.1
PC3LT5	60.1	117.8	57.7	39.4	91.3	51.9
PC6LT8	80.8	136.6	55.8	53.8	105.4	51.6
SC-GHG discounted at 1.5 percent						
PC2LT002	24.5	83.2	58.7	16.2	70.5	54.3
PC1LT3	31.8	118.4	86.6	21.0	99.3	78.3
PC2LT4	47.1	147.4	100.3	31.0	123.4	92.3
PC3LT5	60.1	161.8	101.7	39.4	135.2	95.8
PC6LT8	80.8	187.3	106.6	53.8	156.1	102.3

Table VI-39: Summary of Cumulative Benefits and Costs for CY 2022-2050 (2021$ Billions), by Alternative, SC-GHG Value, and Discount Rate

Alternative	3% Discount Rate			7% Discount Rate		
	Costs	Benefits	Net Benefits	Costs	Benefits	Net Benefits
SC-GHG discounted at 2.5 percent						
PC2LT002	76.8	184.2	107.4	43.6	129.7	86.1
PC1LT3	115.3	282.0	166.8	63.4	197.2	133.9
PC2LT4	175.8	368.4	192.5	96.3	257.5	161.2
PC3LT5	243.4	449.3	205.9	131.9	314.2	182.2
PC6LT8	352.9	611.5	258.6	190.4	426.5	236.1
SC-GHG discounted at 2 percent						
PC2LT002	76.8	236.9	160.1	43.6	182.4	138.8
PC1LT3	115.3	362.2	247.0	63.4	277.4	214.1
PC2LT4	175.8	473.0	297.1	96.3	362.1	265.8
PC3LT5	243.4	577.9	334.4	131.9	442.7	310.7
PC6LT8	352.9	787.5	434.6	190.4	602.5	412.1
SC-GHG discounted at 1.5 percent						
PC2LT002	76.8	336.2	259.3	43.6	281.6	238.0
PC1LT3	115.3	513.3	398.0	63.4	428.5	365.1
PC2LT4	175.8	670.1	494.2	96.3	559.2	462.9
PC3LT5	243.4	820.0	576.5	131.9	684.8	552.9
PC6LT8	352.9	1119.1	766.2	190.4	934.0	743.6

While the results shown in the tables above range widely—underscoring that DR assumptions significantly affect benefits estimates—the ordering of alternatives generally remains the same under most discounting scenarios. In most cases the greatest net benefits are a function of overall alternative stringency, with PC6LT8 having the highest net benefits in most cases. Only in the higher SC–GHG discount rates do the lower stringencies start to show a higher net benefit. Under the No ZEV alternative baseline analysis, results chart a similar path:

Table VI-40: Summary of Cumulative Benefits and Costs for Model Years through MY 2031 (2021$ Billions), by Alternative, SC-GHG Value, and Discount Rate, No ZEV Alternative Baseline Analysis

Alternative	3% Discount Rate			7% Discount Rate		
	Costs	Benefits	Net Benefits	Costs	Benefits	Net Benefits
SC-GHG discounted at 2.5 percent						
PC2LT002	35.4	64.1	28.7	22.6	46.2	23.5
PC1LT3	52.5	88.6	36.1	34.2	63.7	29.5
PC2LT4	62.9	100.3	37.4	41.1	72.0	30.8
PC3LT5	74.2	104.0	29.8	48.7	74.5	25.8
PC6LT8	88.4	107.3	18.9	59.0	76.5	17.5
SC-GHG discounted at 2 percent						
PC2LT002	35.4	80.3	44.9	22.6	62.4	39.8
PC1LT3	52.5	110.7	58.2	34.2	85.8	51.7
PC2LT4	62.9	125.2	62.3	41.1	96.9	55.7
PC3LT5	74.2	129.8	55.6	48.7	100.3	51.6
PC6LT8	88.4	133.8	45.4	59.0	103.0	44.0
SC-GHG discounted at 1.5 percent						
PC2LT002	35.4	110.8	75.4	22.6	92.9	70.3
PC1LT3	52.5	152.3	99.8	34.2	127.4	93.2
PC2LT4	62.9	172.1	109.2	41.1	143.7	102.6
PC3LT5	74.2	178.2	104.0	48.7	148.7	100.0
PC6LT8	88.4	183.6	95.2	59.0	152.8	93.8

Table VI-41: Summary of Cumulative Benefits and Costs for CY 2022-2050 (2021$ Billions), by Alternative, SC-GHG Value, and Discount Rate, No ZEV Alternative Baseline Analysis

Alternative	3% Discount Rate			7% Discount Rate		
	Costs	Benefits	Net Benefits	Costs	Benefits	Net Benefits
SC-GHG discounted at 2.5 percent						
PC2LT002	148.9	339.3	190.4	80.7	236.1	155.5
PC1LT3	222.2	463.4	241.2	120.0	322.8	202.7
PC2LT4	270.3	542.9	272.6	146.0	378.7	232.7
PC3LT5	328.5	608.0	279.6	177.0	424.8	247.8
PC6LT8	402.7	711.8	309.1	216.3	499.5	283.2
SC-GHG discounted at 2 percent						
PC2LT002	148.9	435.7	286.8	80.7	332.6	251.9
PC1LT3	222.2	595.5	373.3	120.0	454.9	334.8
PC2LT4	270.3	698.8	428.4	146.0	534.5	388.5
PC3LT5	328.5	784.5	456.1	177.0	601.3	424.3
PC6LT8	402.7	923.3	520.5	216.3	710.9	494.6
SC-GHG discounted at 1.5 percent						
PC2LT002	148.9	617.3	468.5	80.7	514.2	433.5
PC1LT3	222.2	844.4	622.2	120.0	703.8	583.7
PC2LT4	270.3	992.4	722.0	146.0	828.1	682.1
PC3LT5	328.5	1117.1	788.6	177.0	933.8	756.9
PC6LT8	402.7	1321.8	919.1	216.3	1109.4	893.2

Again, the results shown in the tables above range widely—underscoring that DR assumptions significantly affect benefits estimates. Under the MY accounting approach, PC2LT4 has the greatest net benefits under the various SC–GHG discount rates, and under the CY accounting approach, PC6LT8 has the highest net benefits under the various SC–GHG discount rates.

E.O. 12866 and Circular A–4 direct agencies to consider maximizing net benefits in rulemakings whenever possible and consistent with applicable law. Because it can be relevant to balancing the statutory factors and because it is directed by E.O. 12866 and OMB guidance, NHTSA does evaluate and consider net benefits associated with different potential future CAFE standards. As the tables above show, our analysis suggests that for passenger cars, under either baseline analysis, net benefits tend to be higher when standards are less stringent (and thus anticipated costs are lower). For light trucks, net benefits are higher when standards are more stringent, although not consistently. Looking solely at net benefits, under the reference baseline analysis, PC6LT8 looks best overall and across all DRs, as well as for light trucks specifically, although PC2LT002 is the only non-negative alternative for passenger cars. Under the No ZEV alternative baseline analysis, PC2LT002 is still the only non-negative alternative for passenger cars, but PC1LT3 produces the largest net benefits for the light truck fleet.

That said, while maximizing net benefits is a valid decision criterion for choosing among alternatives, provided that appropriate consideration is given to impacts that cannot be monetized, it is not the only reasonable decision perspective, and we recognize that what we include in our cost-benefit analysis affects our estimates of net benefits. We also note that important benefits cannot be monetized—including the full health and welfare benefits of reducing climate emissions and other pollution, which means that the benefits estimates are underestimates. Thus, given the uncertainties associated with many aspects of this analysis, NHTSA does not rely solely on net benefit maximization, and instead considers it as one piece of information that contributes to how we balance the statutory factors, in our discretionary judgment. NHTSA recognizes that the need of the U.S. to conserve energy weighs importantly in the overall balancing of factors, and thus believes that it is reasonable to at least consider choosing the regulatory alternative that produces the largest reduction in fuel consumption, while still remaining net beneficial. Of course, the benefit-cost analysis is not the sole factor that NHTSA considers in determining the maximum feasible stringency, though it informs NHTSA's conclusion that Alternative PC2LT002 is the maximum feasible stringency. Importantly, the shortfalls discussion above suggests that even if more stringent alternatives appear net beneficial, under the constraints of our standard-setting analysis which is the analysis that NHTSA is statutorily required to consider, hardly any manufacturers would be able to achieve the fuel economy levels required by PC6LT8 considering technologies available under the constrained analysis and planned redesign cycles, and even under the proposal PC2LT4, more than half of manufacturers could not achieve the light truck standards considering technologies available under the constrained analysis and planned redesign cycles. Unachievable standards would not be accomplishing their goals and thus be beyond maximum feasible for purposes of this final rule.

As with any analysis of sufficient complexity, there are a number of critical assumptions here that introduce uncertainty about manufacturer compliance pathways, consumer responses to fuel economy improvements and higher vehicle prices, and future valuations of the consequences from higher CAFE standards. Recognizing that uncertainty, NHTSA prepared an alternative baseline and also conducted more than 60 sensitivity analysis runs for the passenger car and light truck fleet analysis. The entire sensitivity analysis is presented in the FRIA, demonstrating the effect that different assumptions would have on the costs and benefits associated with the different regulatory alternatives. NHTSA's assessment of the final standards as compared to the alternative baseline ensures that the determination that the standards are maximum feasible is robust to the different futures represented by the reference baseline ZEV deployment and the lack of ZEV deployment to satisfy state ZEV standards and non-regulatory manufacturer ZEV deployment in the No ZEV alternative baseline, and thus also to scenarios in between these poles. While NHTSA considers dozens of sensitivity cases to measure the influence of specific parametric assumptions and model relationships, only a small number of them demonstrate meaningful impacts to net benefits under the different alternatives.[1445]

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[1445] For purposes of this table, the IWG SC–GHG sensitivtiy case uses a 2.5% discount rate.

Table VI-42: Summary of Cumulative Benefits and Costs for Model Years Through MY 2031 (2021$ Billions), by Alternative, 2% SC-GHG Discount Rate

Case Name	Costs					Benefits					Net Benefits				
	PC2 LT002	PC1 LT3	PC2 LT4	PC3 LT5	PC6 LT8	PC2 LT002	PC1 LT3	PC2 LT4	PC3 LT5	PC6 LT8	PC2 LT002	PC1 LT3	PC2 LT4	PC3 LT5	PC6 LT8
Reference baseline	24.5	31.8	47.1	60.1	80.8	59.7	85.8	107.2	117.8	136.6	35.2	54.0	60.1	57.7	55.8
No ZEV alternative baseline	35.4	52.5	62.9	74.2	88.4	80.3	110.7	125.2	129.8	133.8	44.9	58.2	62.3	55.6	45.4
Oil price (AEO high)	11.7	37.3	43.2	51.1	68.0	42.6	106.3	118.4	125.2	153.7	30.9	69.0	75.3	74.0	85.6
Oil price (AEO low)	27.3	42.8	54.3	68.3	95.8	60.3	93.2	105.6	110.9	124.2	33.0	50.3	51.2	42.6	28.4
High GDP + fuel (AEO high)	24.5	32.5	48.0	60.9	81.5	61.9	90.0	112.4	123.9	142.8	37.4	57.5	64.4	63.1	61.3
Low GDP + fuel (AEO low)	24.3	31.7	46.9	59.8	80.5	58.1	84.1	104.4	114.6	132.8	33.8	52.4	57.5	54.8	52.3
Standard-setting conditions for MY 2027-2035	25.6	35.0	54.5	64.8	91.1	59.2	84.1	103.7	115.1	132.8	33.6	49.0	49.2	50.3	41.8
Standard-setting conditions for MY 2027-2050	26.7	37.8	59.2	72.6	111.3	58.3	81.9	100.0	109.0	116.9	31.6	44.1	40.8	36.3	5.6
Standard-setting conditions for MY 2023-2050	7.9	19.4	39.6	50.5	91.6	19.8	45.7	62.2	69.2	74.5	11.9	26.3	22.6	18.8	-17.2
IWG SC-GHG[1445]	24.5	31.8	47.1	60.1	80.8	40.0	58.6	73.5	81.0	94.2	15.5	26.8	26.4	20.9	13.4
PEF (NPRM)	24.1	30.6	49.6	55.3	75.2	50.9	78.9	88.3	96.4	107.7	26.9	48.2	38.8	41.1	32.5
PEF (2022 FR)	14.9	23.6	33.9	48.6	70.8	44.5	70.6	94.6	109.3	139.8	29.7	47.0	60.7	60.7	69.0

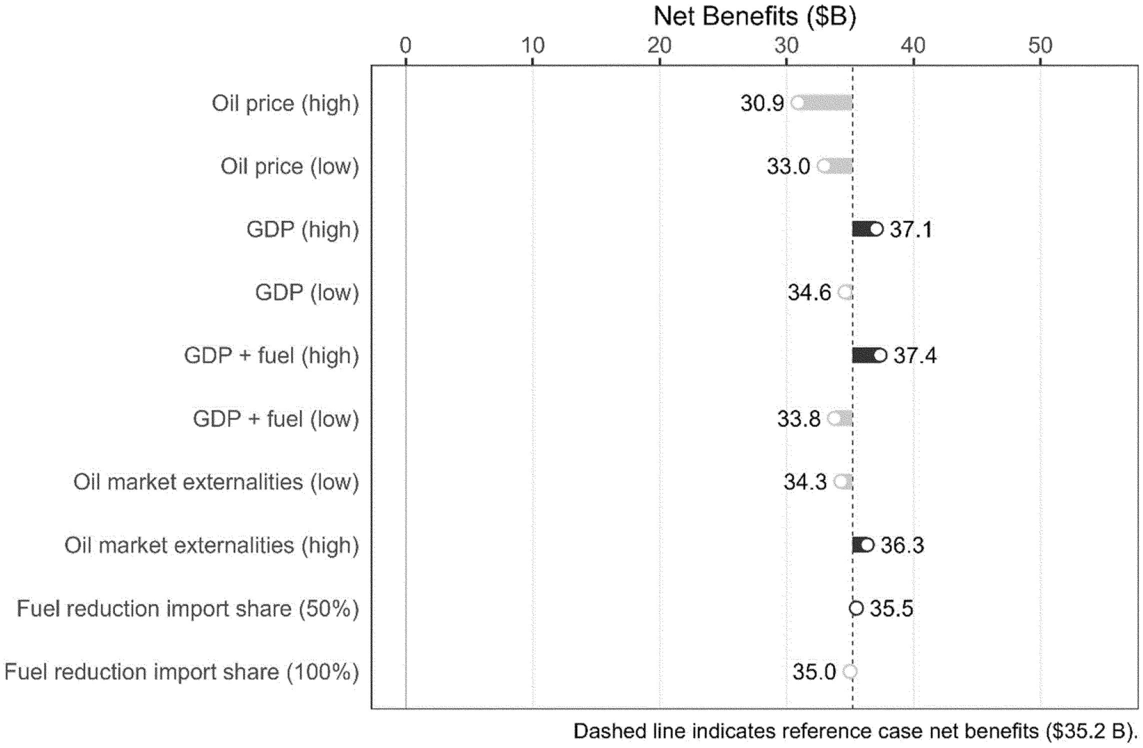

Figure VI-23: Net Benefits for the Lifetime of Vehicles through MY 2031, LD Preferred Alternative Relative to the Reference Case, Macroeconomic Assumptions Sensitivity Cases (2021$, in billions, 3% Social DR, 2% SC-GHG DR)

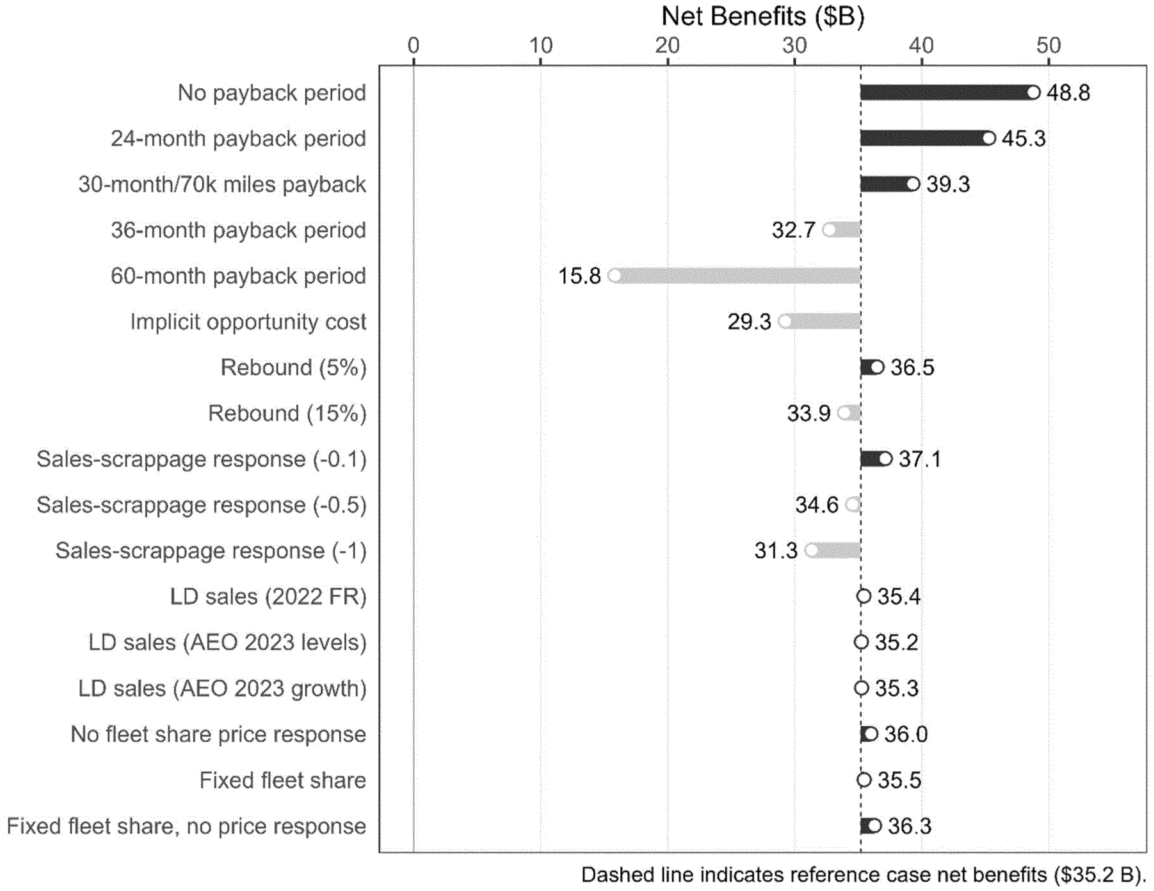

Figure VI-24: Net Benefits for the Lifetime of Vehicles through MY 2031, LD Preferred Alternative Relative to the Reference Case, Payback and Sales Assumptions Sensitivity Cases (2021$, in billions, 3% Social DR, 2% SC-GHG DR)

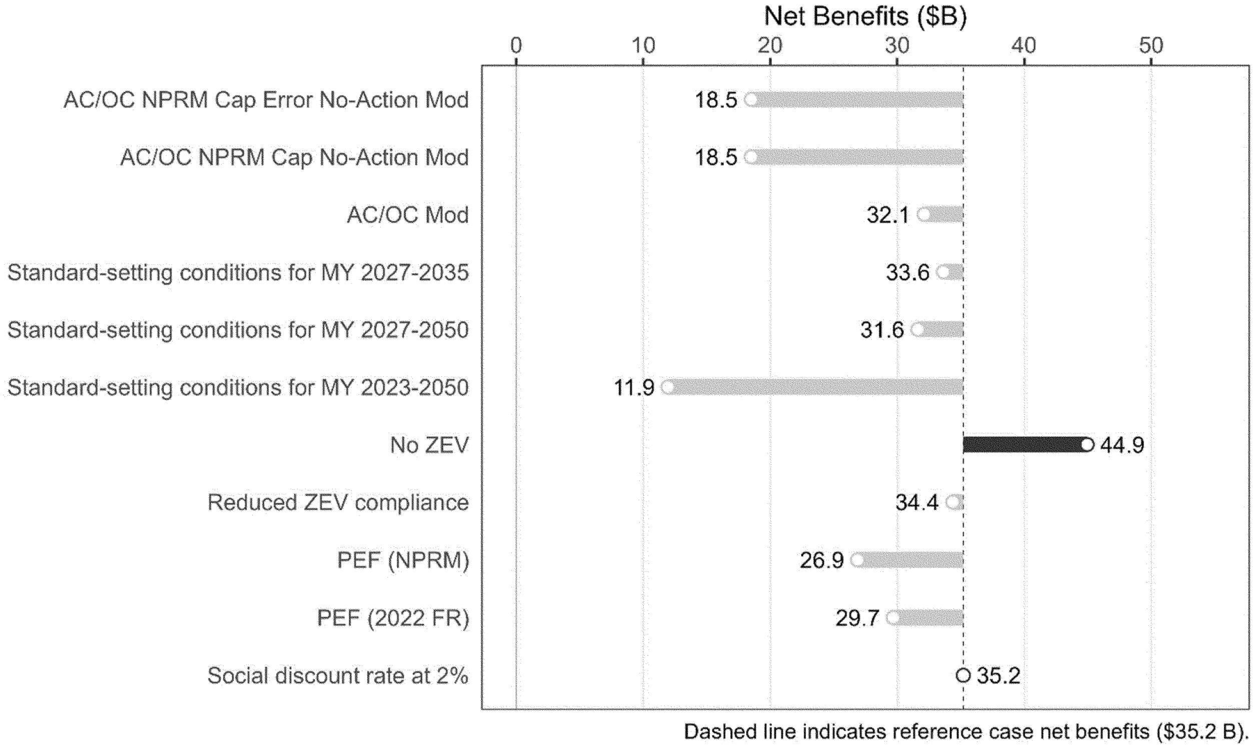

Figure VI-25: Net Benefits for the Lifetime of Vehicles through MY 2031, LD Preferred Alternative Relative to the Reference Case, Policy Assumptions Sensitivity Cases and Alternative Baseline (2021$, in billions, 3% Social DR, 2% SC-GHG DR)

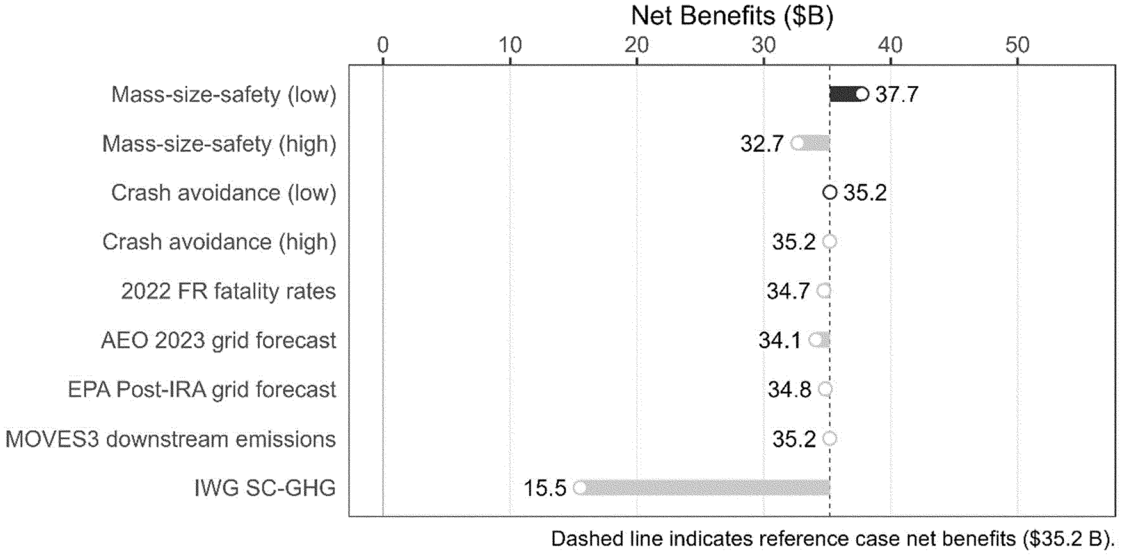

Figure VI-26: Net Benefits for the Lifetime of Vehicles through MY 2031, LD Preferred Alternative Relative to the Reference Case, Safety and Environmental Assumptions Sensitivity Cases (2021$, in billions, 3% Social DR, 2% SC-GHG DR)

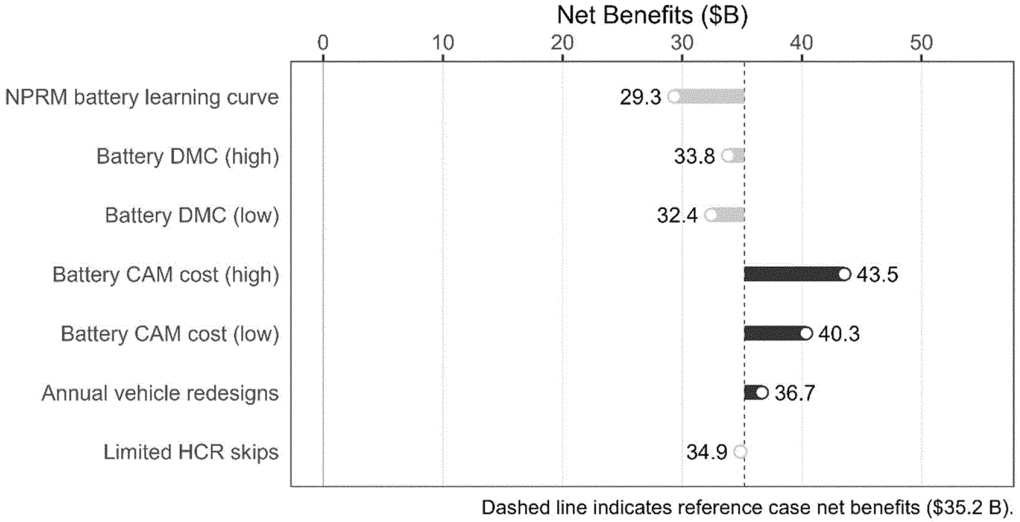

Figure VI-27: Net Benefits for the Lifetime of Vehicles through MY 2031, LD Preferred Alternative Relative to the Reference Case, Technology Assumptions Sensitivity Cases (2021$, in billions, 3% Social DR, 2% SC-GHG DR)

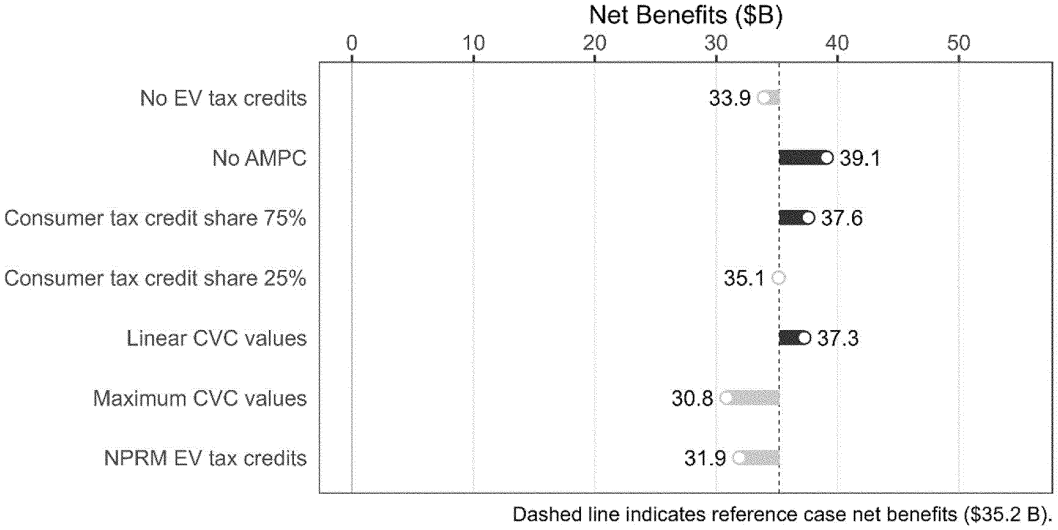

Figure VI-28: Net Benefits for the Lifetime of Vehicles through MY 2031, LD Preferred Alternative Relative to the Reference Case, EV Tax Credit Assumptions Sensitivity Cases (2021$, in billions, 3% Social DR, 2% SC-GHG DR)

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The results of the sensitivity analysis runs suggest that relatively few metrics make major differences to cost and benefit outcomes, and the ones that do, act in relatively predictable ways. Some changes in values (fuel prices, removing ZEV, IRA tax credits) act on the reference baseline, increasing or reducing the amount of fuel economy improvements available for CAFE standards. Other changes in values (for example, fuel prices) affect benefits, and thus net benefits. However, NHTSA's determination of maximum feasible standards does not solely rely on net benefits. That said, it is notable that net benefits remain positive in the vast majority of sensitivity cases, including the most stringent EPCA constraints cases, for the standards being finalized in this notice, PC2LT002, and for the proposed standards, PC2LT4. NHTSA therefore disagrees with commenters that alleged not including EPCA standard setting year constraints in model years other than the standard-setting years affected our decision.

NHTSA is statutorily prohibited from considering the fuel economy of BEVs in determining maximum feasible stringency but notes in passing that the case changing the value of DOE's PEF reduces net benefits somewhat, although not significantly, and that changing assumptions about the value of electrification tax credits that reach consumers also changes net benefits slightly. However, because NHTSA cannot consider the fuel economy of BEVs in determining maximum feasible fuel economy standards, these are effects that happen only in the reference baseline of our analysis and are not considered in our determination. Moreover, regardless of net benefits, NHTSA believes that its conclusion would be the same that Alternative PC2LT002 is economically practicable, based on manufacturers' apparent ability to reach compliance in most model years, considering statutory constraints on technology available to be considered as well as planned redesign cycle constrains, as compared to Alternative PC2LT4 or PC1LT3.

The Alliance created its own sensitivity run by modifying a number of model settings and inputs, including taking BEVs out of the reference baseline, setting PHEV electric operation to zero for all years, setting fine payments to zero, and otherwise keeping standard-setting restrictions. The Alliance noted that compliance appeared much more difficult for a number of manufacturers' fleets under these settings and with these input assumptions. As explained in Section VI.A above, NHTSA modeled an alternative baseline and additional sensitivities similar to the Alliance's test, to evaluate the sensitivity of assumptions surrounding BEVs, including a no ZEV alternative baseline, a reduced ZEV compliance case (which allows for increased use of banked credits in modeling the ACC I program), and three cases that extend EPCA standard setting year constraints (no application of BEVs and no credit use) beyond years considered in the reference baseline.

In the no ZEV alternative baseline, the industry, as a whole, overcomplies with the final standards in every year covered by the standards. The passenger car fleet overcomplies handily, and the light truck fleet overcomplies in model years 2027–2030, until model year 2031 when the fleet exactly meets the standard. Individual manufacturers' compliance results are also much less dramatically affected than comments would lead one to believe; while some manufacturers comply with the 4 percent per year light truck stringency increases from the proposal without ZEV in the baseline, a majority of manufacturers comply in most or all years under the final light truck standards. In general, the manufacturers that have to work harder to comply with CAFE standards without ZEV in the baseline are the same manufacturers that have to work harder to comply with CAFE standards with ZEV in the reference baseline. For example, General Motors sees higher technology costs and civil penalties to comply with the CAFE standards over the five years covered by the standards; however, this is expected as they are starting from a lower baseline compliance position. However, General Motors seems to be the only outlier, and for the rest of the industry technology costs are low and civil penalty payments are nonexistent in many cases.

Similar trends hold true for the EPCA standard setting year constraints cases. Examining the most restrictive case, which does not allow BEV adoption in response to CAFE standards in any year when the CAFE Model adds technology to vehicles (2023–2050, as 2022 is the baseline fleet year), the industry, as a whole, overcomplies in every year from model year 2027–2031, in both the passenger car and light truck fleets. Some manufacturers again struggle in individual model years or compliance categories, but the majority comply or overcomply in both compliance categories of vehicles. Again, General Motors is the only manufacturer that sees notable increases in their technology costs over the reference baseline, however their civil penalty payments are low, at under $500 million total over the five-year period covered by the new standards. Net benefits attributable to CAFE standards do decrease from the central analysis under the EPCA constraints case, but remain significantly positive. In addition, as discussed in more detail below, net benefits are just one of many factors considered when NHTSA sets fuel economy standards.

These alternative baseline and sensitivity cases offer two conclusions. First, contrary to the Alliance's and other commenter's concerns, the difference between including BEVs for non-CAFE reasons and excluding them are not great—thus, NHTSA would make the same determination of what standards are maximum feasible under any of the analyzed scenarios.[1446] NHTSA does not mean that it is *considering* the electric vehicles in these various baselines (and thus the fuel economy inherent in the BEVs they include or do not include) in determining the maximum feasible CAFE standards; NHTSA means instead that it developed an alternative baseline in response to comments and that the inclusion or exclusion of BEVs in the analytical reference baseline would not lead NHTSA to make a different decision on maximum feasible standards. And second, this lack of dispositive difference in the various baselines shows that the interpretive concerns raised by commenters, even if correct, would not lead to a different decision by NHTSA on the question of what is maximum feasible.

Finally, as discussed in Section IV.A, NHTSA accounts for the effects of other motor vehicle standards of the Government in its balancing, often through their incorporation into our regulatory reference baseline.[1447] NHTSA believes that this approach accounts for these effects reasonably and appropriately. Some commenters requested that NHTSA ''keep pace'' with EPA's standards specifically, (*i.e.,* that NHTSA should choose a more stringent alternative in the final rule), while other commenters requested that NHTSA set CAFE standards such that no additional investment in fuel economy-improving technologies would be necessary beyond what manufacturers intended to make to meet EPA's GHG standards (*i.e.,* that NHTSA should choose a less stringent alternative in the final rule). NHTSA can only ''keep pace'' with EPA's standards (or government-wide transportation decarbonization plans, or even Executive Orders) to the extent permitted by statute, specifically to the extent permitted by our statutory restrictions on considering the fuel economy of BEVs in determining what levels of CAFE standards would be maximum feasible. Conversely, while NHTSA coordinates closely with EPA in developing and setting CAFE standards, as discussed above, even when the standards of the two programs are coordinated closely, it is still foreseeable that there could be situations in which different agencies' programs could be binding for different

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[1446] See RIA Chapter 9 for sensitivity run results.

[1447] NHTSA has carefully considered EPA's standards by including the baseline (*i.e.,* model years 2024–2026) CO_2 standards in our analytical baseline. Because the EPA and NHTSA final rules were developed in coordination jointly, and stringency decisions were made in coordination, NHTSA did not include EPA's final rule for model years 2027 and beyond CO_2 standards in our analytical baseline for this final rule. The fact that EPA issued its final rule before NHTSA is an artifact of circumstance only.

manufacturers in different model years. This has been true across multiple CAFE rulemakings over the past decade. Regardless of which agency's standards are binding given a manufacturer's chosen compliance path, manufacturers will choose a path that complies with both standards, and in doing so, will still be able to build a single fleet of vehicles—even if it is not exactly the fleet that the manufacturer might have preferred to build. This remains the case with this final rule.

NHTSA continues to disagree that it would be a reasonable interpretation of Congress' direction to set ''maximum feasible'' standards, as some commenters might prefer, at the fuel economy level at which no manufacturer need ever apply any additional technology or spend any additional dollar beyond what EPA's standards, with their many flexibilities, would require. NHTSA believes that CAFE standards can still be consistent with EPA's GHG standards even if they impose additional costs for certain manufacturers, although NHTSA is, of course, mindful of the magnitude of those costs and believes that the preferred alternative would impose minimal additional costs, if any, above compliance with EPA's standards.

Some commenters also asked NHTSA to set standards that ''keep pace'' with CARB's programs, *i.e.* to set standards that mandate BEVs or lead to a ban on ICEVs. As discussed above, NHTSA cannot mandate BEVs or ban ICEVs, due to the statutory restrictions in 49 U.S.C. 32902(h).[1448] NHTSA continues to believe that accounting for CARB's programs that have been granted a waiver by including them in the regulatory reference baseline is reasonable. NHTSA has not included CARB's ACC II program (which includes the ZEV program) as a legal requirement by including it in the No-Action Alternative, because it has not been granted a Clean Air Act preemption waiver. However, NHTSA did use ACC II levels of electrification as a proxy for the electric vehicle deployment that automakers have committed to executing, regardless of legal requirements. Modeling anticipated manufacturer compliance with ACC I and ACT and the additional electric vehicles that manufacturers have committed to deploy enables NHTSA to make more realistic projections of how the U.S. vehicle fleet will change in the coming years independent of CAFE standards, which is foundational to our ability to set CAFE standards that reflect the maximum feasible fuel economy level achievable through improvements to internal combustion vehicles. Likewise, by creating a more accurate projection of how manufacturers might modify their fleets even in the absence of new CAFE standards, we are better able to identify the effects of new *CAFE standards,* which is the task properly before us. If NHTSA could not account for the ACC I program and could not be informed about its *reference baseline* effects, then NHTSA could overestimate the availability of internal combustion engine vehicles that can be improved to meet potential new CAFE standards, and thus end up setting a fuel economy standard that requires an infeasible level of improvement. Moreover, as the No ZEV alternative baseline shows, the effect of including the ACC I program and additional electric vehicle deployment that manufacturers intend to implement in the reference baseline is simply to decrease costs and benefits attributable to potential future CAFE standards. Removing these electric vehicles from the reference baseline increases costs and benefits for nearly every alternative, but even so, we note that net benefits change relatively little for that alternative baseline, as shown in more detail in Table VI–43. While PC2LT4 looks slightly more net beneficial than PC2LT002 under that case, it is relatively slightly, and it is not so great an effect as to change NHTSA's balancing of the statutory factors in this final rule. NHTSA continues to believe, even under this scenario, that PC2LT002 is maximum feasible for the rulemaking time frame.

Even though NHTSA is statutorily prohibited from considering the possibility that manufacturers would produce additional BEVs to comply with CAFE standards, and even though manufacturers have stated their intention to rely more and more heavily on those BEVs for compliance, CAFE standards still have an important role to play in meeting the country's ongoing need to conserve energy. CAFE standards can also ensure continued improvements in energy conservation by requiring ongoing fuel economy improvements even if demand for more fuel economy flags unexpectedly, or if other regulatory pushes change in unexpected ways. Saving money on fuel and reducing CO_2 and other pollutant emissions by reducing fuel consumption are also important equity goals. As discussed by some commenters, fuel expenditures are a significant budget item for consumers who are part of lower-income and historically disadvantaged communities. By increasing fuel savings to consumers (given estimated effects on new vehicle costs), CAFE standards can help to improve equity. NHTSA believes, moreover, that the final CAFE standards will improve the affordability of new vehicles relative to the proposal, and will continue to preserve consumer choice, while still contributing to the nation's need to conserve energy and improve energy security.

That said, NHTSA continues to acknowledge the statute-driven cognitive dissonance, and NHTSA's task in approaching the determination of maximum feasible standards is the same as ever, to evaluate potential future CAFE stringencies in light of statutory constraints. NHTSA has listened carefully to commenters and is establishing final standards that it believes are technologically feasible and economically practicable within the context of the statutory constraints. The rate of increase in the standards may be slower than in the last round of rulemaking, but NHTSA believes that is reasonable and appropriate given the likely state of the fleet by model year 2027.[1449] Consider, for example, the non-linear relationship between fuel economy and fuel consumption (in the absence of new technological innovations) as illustrated below:

[1448] NHTSA thus also cannot be part of any supposed strategy to force manufacturers to produce BEVs or consumers to purchase BEVs. On the compliance side of this equation, just as NHTSA cannot force manufacturers to use BEVs to comply, so NHTSA cannot force manufacturers *not* to use BEVs to comply (and instead improve the fuel economy of their ICEV models), contrary to the assertions of several industry commenters. Manufacturers are always free to use whatever technology they choose to meet the CAFE standards.

[1449] Moreover, if future information indicates that NHTSA's conclusions in this regard are incorrect, NHTSA always has authority to amend fuel economy as long as lead-time requirements are respected, if applicable. *See* 49 U.S.C. 32902(g).

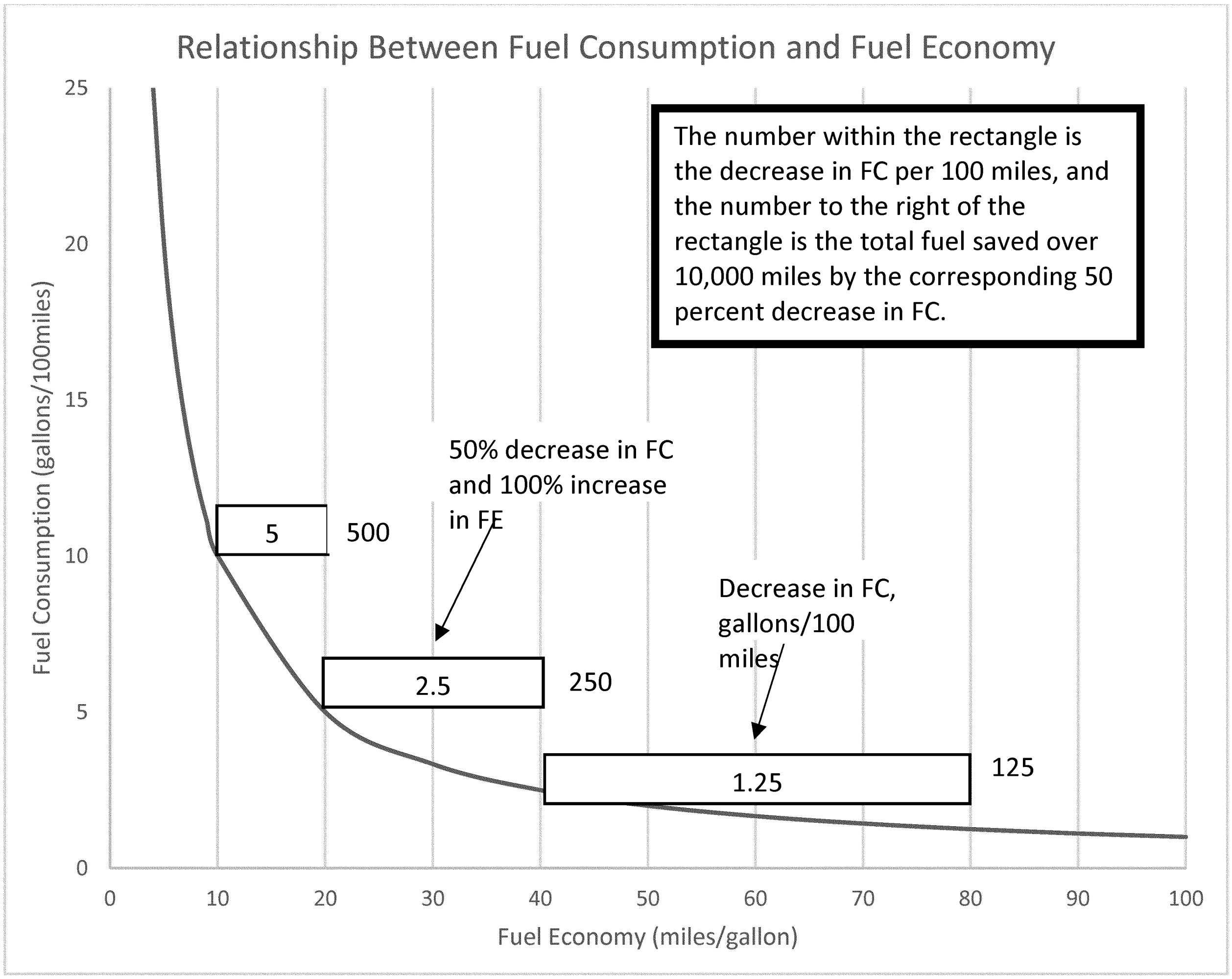

Figure VI-29: Relationship Between Fuel Consumption and Fuel Economy

As fleet fuel economy improves, there are simply fewer further improvements to ICEs available to be made (in the absence of further technological innovation), and the amount of fuel consumers actually save is smaller, *and* the remaining available improvements are increasingly expensive. This is even more true given the statutory restrictions that NHTSA must observe, which precludes NHTSA from incorporating the set of technologies deployed in electric vehicles that is evolving most rapidly right now. CAFE standards can still help industry further improve internal combustion engine vehicles, and as such, based on all of the information contained in this record, NHTSA concludes that PC2LT002 represents the maximum feasible standards for passenger cars and light trucks in the model years 2027 to 2031 time frame.

NHTSA also conducted an analysis using an alternative baseline, under which NHTSA removed not only the electric vehicles that would be deployed to comply with ACC I, but also those that would be deployed consistent with manufacturer commitments to deploy additional electric vehicles regardless of legal requirements, consistent with the levels under ACC II. NHTSA describes this as the ‘‘No ZEV alternative baseline.’’ Under the No ZEV alternative baseline, NHTSA generally found that benefits and costs attributable to the CAFE standards were higher than under the reference case baseline, and that net benefits were also higher. Removing some electric vehicles, as under the No ZEV alternative baseline, increases the share of other powertrains in the No Action alternative. The preferred alternative results in more SHEVs and fewer PHEVs than when compared to the reference baseline case. Relative to the reference baseline, total technology costs and civil penalties for the passenger car and light truck fleets increase somewhat under PC2LT002, but not by enough to alter NHTSA's conclusion. Chapter 8.2.7 of the FRIA presents these results in more detail. Based on these results, NHTSA concludes that it would continue to find PC2LT002 to be maximum feasible fuel economy level that manufacturers can achieve even under the No ZEV alternative baseline.

NHTSA's conclusion, after consideration of the factors described below and information in the administrative record for this action, is that 2 percent increases in stringency for passenger cars for model years 2027–2031, 0 percent increases in stringency for light trucks in model years 2027–2028, and 2 percent increases in stringency for model years 2029–2031 (Alternative PC2LT002) are maximum feasible. EPCA requires NHTSA to consider four factors in determining what levels of CAFE standards (for passenger cars and light trucks) would be maximum feasible—technological feasibility, economic practicability, the effect of other motor vehicle standards of the Government on fuel economy, and the need of the United States to conserve energy.

''Technological feasibility'' refers to whether a particular method of improving fuel economy is available for deployment in commercial application in the model year for which a standard is being established. The technological feasibility factor allows NHTSA to set standards that force the development and application of new fuel-efficient technologies, recognizing that NHTSA may not consider the fuel economy of BEVs when setting standards. Given the statutory constraints under which NHTSA must operate, and constraining technology deployment to what is feasible under expected redesign cycles, NHTSA does not see a technology path to reach the higher fuel economy levels that would be required by the more stringent alternatives, in the time frame of the rulemaking. NHTSA's final rule (constrained) analysis illustrates that a number of manufacturers do not have enough opportunities to redesign enough vehicles during the rulemaking time frame in order to achieve the levels estimated to be required by the more stringent alternatives. NHTSA also finds that using the No ZEV alternative baseline would not change our conclusions regarding the technological feasibility of the various action alternatives—rather, it reinforces those conclusions. NHTSA therefore concludes that the final standards are technologically feasible, but the most stringent alternatives are not technologically feasible, considering redesign cycles, without widespread payment of penalties.

''Economic practicability'' has consistently referred to whether a standard is one ''within the financial capability of the industry, but not so stringent as to'' lead to ''adverse economic consequences, such as a significant loss of jobs or unreasonable elimination of consumer choice.''[1450] While NHTSA is prohibited from considering the fuel economy of BEVs in determining maximum feasible CAFE standards, NHTSA does not believe that it is prohibited from considering *the industry resources needed to build BEVs,* and industry is adamant that the resource load it faces as part of this technological transition to electric vehicles is unprecedented. Specifically, NHTSA believes it can consider the reality that given the ongoing transition to electric vehicles, fuel economy standards set at a level that resulted in widespread payment of penalties rather than compliance would be counterproductive to the core aim of the statute we are implementing, which is improving energy conservation. Such widespread payment of penalties at the precise time when manufacturers are concentrating available resources on a transition to electrification which will itself dramatically improve fuel economy and energy conservation would be at cross purposes with the statute. Further, while NHTSA does not believe that economic practicability mandates that zero penalties be modeled to occur in response to potential future standards, NHTSA does believe that economic practicability cannot reasonably include the idea that high percentages of the cost of compliance would be attributed to shortfall penalties across a wide group of manufacturers, because penalties are not compliance. The number of manufacturers facing shortfalls (particularly in their imported car fleets) and the percentage of regulatory costs represented by civil penalties rapidly increase for the highest stringency scenarios considered, PC3LT5 and PC6LT8, such that at the highest stringency 43 percent of the regulatory cost is attributed to penalties and approximately three quarters of the 19 manufacturers are facing shortfalls. The three less stringent alternatives show only one manufacturer facing shortfalls for each of the alternatives PC2LT002, PC1LT3, and PC2LT4. Moreover, civil penalties represent higher percentages of regulatory costs under PC1LT3 and PC2LT4 than under PC2LT002. Evaluating the alternatives against the No ZEV alternative baseline further reinforces these trends. Optimizing the use of resources for technology improvement rather than penalties suggests PC2LT002 as the best option of the three for the passenger car fleet. Considering this ratio as an element of economic practicability for purposes of this rulemaking, then, NHTSA believes that PC2LT002 represents the least harmful alternative considered given the need for industry resources to be dedicated to the ongoing transition to electrification.

''The effect of other motor vehicle standards of the Government on fuel economy'' involves analysis of the effects of compliance with emission, safety, noise, or damageability standards on fuel economy capability, and thus on industry's ability to meet a given level of CAFE standards. In many past CAFE rulemakings, NHTSA has said that it considers the adverse effects of other motor vehicle standards on fuel economy. Because the EPA and NHTSA programs were developed in coordination, and stringency decisions were made in coordination, NHTSA has not incorporated EPA's CO_2 standards for model years 2027–2032 as part of the analytical reference baseline for this final rule's main analysis. The fact that EPA finalized its rule before NHTSA is an artifact of circumstance only. NHTSA recognizes, however, that the CAFE standards thus sit alongside EPA's light-duty multipollutant emission standards that were issued in March. NHTSA also notes that any electric vehicles deployed to comply with EPA's standards will count toward real-world compliance with these fuel economy standards. In this final rule, NHTSA's goal has been to establish regulations that achieve energy conservation per its statutory mandate and consistent with its statutory constraints, and that work in harmony with EPA's regulations addressing air pollution. NHTSA believes these standards meet that goal.

NHTSA has consistently interpreted ''the need of the United States to conserve energy'' to mean ''the consumer cost, national balance of payments, environmental, and foreign policy implications of our need for large quantities of petroleum, especially imported petroleum.'' As discussed above, when considered in isolation, the more stringent alternatives better satisfy this objective, whether compared against the reference baseline or the No ZEV alternative baseline. However, taking the widespread penalty payment that is projected to occur under the more stringent alternatives into account, and the resulting diversion of resources from the electrification transition to penalty payments, the more stringent alternatives would not likely further energy conservation in implementation.

In summary, when compared to either the reference case baseline or the No ZEV alternative baseline, NHTSA believes that the technology ''available'' for manufacturers to comply under the statutory constraints, combined with the relatively few opportunities for vehicle redesigns, simply put the more stringent action alternatives out of reach for certain manufacturers during the rulemaking time frame and resulted in unacceptably high levels of penalty payments rather than fuel economy improvements. NHTSA further notes that these penalty payments would divert resources from the ongoing electrification transition, in a manner that would be at cross-purposes with the energy conservation aims of the statute. Finally, NHTSA finds that the economic practicability factor is not satisfied where penalty payments are projected to comprise such a high penalty payment levels would also reduce resources

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[1450] 67 FR 77015, 77021 (Dec. 16, 2002).

available to manufacturers to invest in the transition to electric vehicles, which they have indicated they are undertaking and which will have very significant fuel economy benefits. NHTSA therefore concludes that PC2LT002 is maximum feasible for passenger cars and light trucks for MYs 2027–2031.

2. Heavy-Duty Pickups and Vans

NHTSA has not set new HDPUV standards since 2016. The redesign cycles in this segment are slightly longer than for passenger cars and light trucks, roughly 6–7 years for pickups and roughly 9 years for vans.[1451] To our knowledge, technology for pickups in this segment has been relatively slow to advance compared to in the light truck segment, and there are still no hybrid HD pickups. That said, electrification is beginning to appear among the vans in this segment, perhaps especially among vans typically used for deliveries,[1452] and under NHTSA's distinct statutory authority for setting HDPUV standards, expanding BEV technologies are part of NHTSA's standard setting consideration. The Ford E-Transit, for example, is based on the Mach-E platform and uses similar battery architecture; [1453] other manufacturers have also shown a willingness to transition to electric vans and away from conventional powertrains.[1454] NHTSA is aware that some historic light truck applications now being offered as BEVs may be heavy enough to fall outside the light truck segment and into the HDPUV segment,[1455] but NHTSA expects manufacturers to find strategies to return them to the CAFE light truck fleet in the coming years. This could include development in battery design or electrified powertrain architecture that could reduce vehicle weight. The vehicles in these segments are purpose-built for key applications and we expect manufacturers will cater electrified offerings for businesses that maximize benefits in small volumes. However, until these technologies materialize, NHTSA assumes in its analysis there will continue to be 'spill-over' of vehicles that exist as edge cases, and that they will count toward HDPUV compliance.

NHTSA proposed HDPUV standards that would increase at 10 percent per year, each year, for the 3-year periods of model years 2030–2032 and model years 2033–2035 (the preferred alternative in the proposal was designated as ''HDPUV10''). NHTSA acknowledged in the proposal that more stringent standards, as represented by HDPUV14, appeared to be potentially appropriate, cost-effective, and technologically feasible. However, NHTSA was concerned that the nature of the HDPUV fleet—with many fewer different models than the passenger car and light truck fleets over which improvements could be spread—could lead to significant negative implications if certain of NHTSA's assumptions turned out to be incorrect, such as assumptions about battery costs or future gasoline prices, significantly raising costs and reducing benefits.[1456] Significantly different cost and benefit assumptions can change both the cost-effectiveness and the appropriateness of potential new HDPUV standards. NHTSA therefore proposed HDPUV10 rather than HDPUV14 out of an abundance of caution given the wish to support and not hinder the technological transition anticipated to occur leading up to and during the rulemaking time frame.[1457]

Some commenters encouraged NHTSA to finalize more stringent HDPUV standards. MPCA commented that NHTSA should finalize standards at least as stringent as proposed, because more stringent standards would reduce fossil fuel use, save consumers money, and be better for the environment.[1458] A number of commenters urged NHTSA to finalize more stringent standards on the basis that the ''appropriate'' factor includes ''a variety of factors related to energy conservation, including average estimated fuel savings to consumers, average estimated total fuel savings, benefits to U.S. energy security, and environmental benefits, including avoided emissions of criteria pollutants, air toxics, and CO_2 emissions,'' stating that all of these point toward higher standards.[1459] Commenters also noted environmental justice benefits, and that reductions in consumer fuel costs ''make a meaningful difference to low-income households and households of color that generally spend a greater proportion of their income on transportation costs.'' [1460] Public Citizen focused on public health concerns, stating that ''Vehicle pollution is a major contributor to the unhealthy air pollution levels affecting more than 1 in 3 Americans, which is linked to numerous health problems and thousands of premature deaths. Heavy duty vehicles are particularly problematic. Their fumes create ''diesel death zones'' with elevated levels of asthma rates and cancer risks.'' [1461] Ceres commented that it had found that HDPUV14 would be best for the competitiveness of the auto industry.[1462]

[1451] See TSD Chapter 2.2.1.7. HDPUVs have limited makes and models. Assumptions about their refresh and redesign schedules have an outsized impact on our modeling of HDPUVs, where a single redesign can have a noticeable effect on technology penetration, costs, and benefits.

[1452] North American Council for Freight Efficiency (NACFE). 2022. Electric Trucks Have Arrived: The Use Case For Vans and Step Vans. Available at: *https://nacfe.org/research/run-on-less-electric/#vans-step-vans.* (Accessed: Feb. 28, 2024).

[1453] Martinez, M. 2023. Ford to Sell EVs With 2 Types of Batteries, Depending On Customer Needs. Automotive News. Last revised: Mar. 5, 2023. Available at: *https://www.autonews.com/technology/ford-will-offer-second-ev-battery-type-lower-cost-and-range.* (Accessed: Feb. 28, 2024).

[1454] Hawkins, T. 2023. Mercedes-Benz eSprinter Unveiled As BrightDrop Zevo Rival. GM Authority. Available at: *https://gmauthority.com/blog/2023/02/mercedes-benz-esprinter-unveiled-as-brightdrop-zevo-rival/.* (Accessed: Feb. 28, 2024).

[1455] Gilboy, J. 2023.Massive Weight Could Push Past EPA's Light-Duty Rules. The Drive. Available at: *https://www.thedrive.com/news/the-2025-ram-1500-revs-massive-weight-could-push-past-epas-light-duty-rules.* (Accessed Feb. 27, 2024); See also Arbelaez, R. 2023. IIHS Insight. As Heavy EVs Proliferate, Their Weight May Be a Drag on Safety. Available at: *https://www.iihs.org/news/detail/as-heavy-evs-proliferate-their-weight-may-be-a-drag-on-safety.* (Accessed Feb. 27, 2024).

[1456] *See* 88 FR at 56358 (Aug. 17, 2023).

[1457] NHTSA reminds readers that 49 U.S.C. 32902(h) does not apply to HDPUV standards set under 32902(k) and (b), and thus that NHTSA may, in setting HDPUV standards, consider the reality of the electric vehicle transition.

[1458] MPCA, Docket No. NHTSA–2023–0022–60666, at 1.

[1459] NESCAUM, Docket No. NHTSA–2023–0022–57714, at 4; SELC, Docket No. NHTSA–2023–0022–60224, at 4, 6; Public Citizen, Docket No. NHTSA–2023–0022–57095, at 1; Colorado State Agencies, Docket No. NHTSA–2023–0022–57625, at 2; OCT, Docket No. NHTSA–2023–0022–51242, at 2–4; BICEP Network, Docket No. NHTSA–2023–0022–61135, at 1.

[1460] SELC, Docket No. NHTSA–2023–0022–60224, at 4, 6; Public Citizen, Docket No. NHTSA–2023–0022–57095, at 1; Colorado State Agencies, Docket No. NHTSA–2023–0022–57625, at 2; OCT, Docket No. NHTSA–2023–0022–51242, at 2–4; BICEP Network, Docket No. NHTSA–2023–0022–61135, at 1.

[1461] Public Citizen, Docket No. NHTSA–2023–0022–57095, at 2.

[1462] Ceres, Docket No. NHTSA–2023–0022–28667, at 1.

Tesla and ZETA stated that HDPUV14 is best for the environment, energy security, and has the largest net benefits.[1463] Rivian also commented that NHTSA should finalize HDPUV14, because ''(1) NHTSA shows that, of the alternatives considered, HDPUV14 delivers the greatest net benefits; (2) The agency's analysis acknowledges that HDPUV14 is feasible; (3) NHTSA does not appear to account for Rivian's Class 2b commercial van or the impact of the Advanced Clean Fleets ('ACF') rule.'' [1464] Several commenters argued that NHTSA should finalize more stringent standards because they would be technologically feasible and cost-effective, and because NHTSA is allowed to consider BEVs, PHEVs, FCEVs, and other technologies for HDPUV.[1465]

IPI agreed that HDPUV14 was clearly the most ''appropriate,'' and argued that NHTSA should not have proposed HDPUV10 based only on 3 of dozens of sensitivities, without explaining why those are the relevant or likely ones or reporting net benefits under those sensitivities. IPI stated that NHTSA should have conducted a Monte Carlo analysis for HDPUV instead. IPI also argued that NHTSA's cost estimates for the proposal and alternatives were inflated because NHTSA holds manufacturer fleet share fixed in response to the standards.[1466]

Some commenters supported standards closer to the proposal. Some commenters supported HDPUV10 as maximum feasible.[1467] The Alliance stated that HDPUV10 could be acceptable, but only through model year 2032, because of the uncertainty that NHTSA had discussed in the NPRM, especially regarding consumer acceptance and infrastructure development.[1468] The Alliance further stated that if NHTSA must set standards through model year 2035, then standards should increase only 4 percent per year for model years 2033–2035, or 7 percent per each year for model years 2030–2035.[1469] MEMA agreed that 10 percent per year increases in model years 2033–2035 were challenging and stated that NHTSA should ''more carefully analyze the assumptions and conditions needed.''[1470]

Other commenters argued that the proposed standards were too stringent,[1471] for a variety of reasons. NTEA commented that NHTSA should finalize the No-Action alternative because today's trucks are already 98 percent cleaner than pre-2010 trucks, and making trucks more expensive will discourage consumers from buying them.[1472] Valero commented that the proposed fuel efficiency standards for CI engines are beyond maximum feasible and reduce the number of CI HDPUV models to zero by model year 2031. Valero stated that NHTSA also eliminates any diesel engine hybridization from the model entirely, which is neither technologically feasible nor economically practicable as not a single CI HDPUV in the model year 2030 analysis fleet would meet the proposed standards without becoming a BEV or a gasoline SHEV.[1473] Valero concluded that ''The rule effectively kills diesel engines for eternity without ever once addressing whether NHTSA even has the legal authority to work such a huge transformation on the transportation sector in the United States—clearly a question of ''vast economic and political significance,'' and argued that NHTSA has recognized that under all its scenarios, its modeling has reduced ''the use of ICE technology . . . to only a few percentage points'' with most of the new technology penetration coming from BEVs. The baseline HDPUV fleet had 0% hybrids and only 6% BEVs. This is nothing short of a momentous shift in only 8 years.'' [1474] Elsewhere, Valero argued that the proposed standards relied entirely on changes in the reference baseline, and that the proposed standards themselves contribute nothing (*i.e.,* that the reference baseline assumptions are excessive).[1475] API argued that NHTSA does not have authority to impose standards that effectively require a portion of the fleet to be BEV.[1476] AVE stated that NHTSA should align with EPA's rule.[1477]

RFA *et al.* 2 argued that NHTSA is required to analyze critical mineral supply and charging infrastructure as part of technological feasibility because the standards are based on the reference baseline, and NHTSA had not proven that the reference baseline is feasible even though ''comparing regulatory alternatives to a baseline is customary.'' [1478] These commenters also stated that NHTSA did not address consumer demand for BEVs.[1479] RVIA expressed concern that motor homes would not recoup the cost increases estimated for the proposed standards because they are only driven sparingly.[1480]

The following text will walk through the three statutory factors in more detail and discuss NHTSA's decision-making process more thoroughly. The balancing of factors presented here represents NHTSA's thinking at the present time, based on all of the information presented in the public comments and in the record for this final rule.

For the reader's reference, the regulatory alternatives under consideration for HDPUVs are presented again below:

[1463] Tesla, Docket No. NHTSA–2023–0022–60093, at 14; ZETA, Docket No. NHTSA–2023–0022–60508, at 1.

[1464] Rivian, Docket No. NHTSA–2023–0022–59765, at 11.

[1465] NESCAUM, Docket No. NHTSA–2023–0022–57714, at 4; Public Citizen, Docket No. NHTSA–2023–0022–57095, at 2; OCT, Docket No. NHTSA–2023–0022–51242, at 3.

[1466] IPI, Docket No. NHTSA–2023–0022–60485, at 12–16. NHTSA discusses the topic of fleet share in more detail in Section III, but notes here that IPI's suggested approach is currently not congruent with our analytical structure and the information we have from manufacturers.

[1467] Arconic, Docket No. NHTSA–2023–0022–48374, at 3; DC Government Agencies, Docket No. NHTSA–2023–0022–27703, at 1.

[1468] The Alliance, Docket No. NHTSA–2023–0022–60652, Appendix F, at 63.

[1469] The Alliance, Docket No. NHTSA–2023–0022–60652, Appendix F, at 63.

[1470] MEMA, Docket No. NHTSA–2023–0022–59204–A1, at 3.

[1471] *See, e.g.,* Heritage Foundation, Docket No. NHTSA–2023–0022–61952, at 2; The Alliance, Docket No. NHTSA–2023–0022–60652, Attachment 2, at 13.

[1472] NTEA—The Work Truck Association, Docket No. NHTSA–2023–0022–60167, at 2.

[1473] Valero, Docket No. NHTSA–2023–0022–58547, Attachment A, at 11, and Attachment G, at 9.

[1474] Valero, Docket No. NHTSA–2023–0022–58547, Attachment A, at 11.

[1475] Valero, Docket No. NHTSA–2023–0022–58547, Attachment G, at 1.

[1476] API, Docket No. NHTSA–2023–0022–60234, at 4.

[1477] AVE, Docket No. NHTSA–2023–0022–60213, at 2.

[1478] RFA *et al.* 2, Docket No. NHTSA–2023–0022–57625, at 16–18.

[1479] RFA *et al.* 2, Docket No. NHTSA–2023–0022–57625, at 16–18.

[1480] RVIA, Docket No. NHTSA–2023–0022–51462, at 2. As discussed above, motor homes fall under NHTSA's vocational vehicle standards per the Phase 2 HD rule, and therefore they are not subject to the HDPUV standards being finalized as part of this rulemaking.

Table VI-43: Regulatory Alternatives Under Consideration for MYs 2030-2035 HDPUVs

Name of Alternative	HDPUV Stringency Increases, Year-Over-Year
No-Action Alternative	n/a
Alternative HDPUV4	4%
Alternative HDPUV108 (Preferred Alternative)	10% for MYs 2030-2032, 8% for MYs 2033-2035
Alternative HDPUV10	10%
Alternative HDPUV14	14%

As discussed in Section VI.A, the three statutory factors for HDPUV standards are similar to and yet somewhat different from the four factors that NHTSA considers for passenger car and light truck standards, but they still modify ''feasible'' in ''maximum feasible.'' NHTSA also interprets the HDPUV factors as giving us broad authority to weigh potentially conflicting priorities to determine maximum feasible standards. It is firmly within NHTSA's discretion to weigh and balance the HDPUV factors in a way that is technology-forcing, although NHTSA would find a balancing of the factors in a way that would require the application of technology that will not be available in the lead time provided by this final rule, or that is not cost-effective, to be beyond maximum feasible.

That said, because HDPUV standards are set in accordance with 49 U.S.C. 32902(k), NHTSA is not bound by the 32902(h) factors when it determines maximum feasible HDPUV standards.[1481] That means that NHTSA may, and does, consider the full fuel efficiency of BEVs and PHEVs, and that NHTSA may consider the availability and use of overcompliance credits, in this final rule. These considerations thus play a role in NHTSA's balancing of the HDPUV factors, as described below.

In evaluating whether HDPUV standards are appropriate, NHTSA could begin by seeking to isolate the effects of new HDPUV standards from NHTSA, by understanding effects in the industry that appear to be happening for reasons other than potential new NHTSA regulations. NHTSA explained in Chapter 1.4.1 of the TSD that the No-Action Alternative for HDPUV accounts for existing technology on HDPUVs, technology sharing across platforms, manufacturer compliance with existing HDPUV standards from NHTSA and EPA (*i.e.,* those standards set in the Phase 2 final rule in 2016 for model year 2021 to model year 2029), manufacturer compliance with California's ACT and ZEV programs, and foreseeable voluntary manufacturer application of fuel efficiency-improving technologies (whether because of tax credits or simply because the technologies are estimated to pay for themselves within 30 months). One consequence of accounting for these effects in the No-Action Alternative is that the effects of the different regulatory alternatives under consideration appear less cost-beneficial than they would otherwise. Nonetheless, NHTSA believes that this is reasonable and appropriate to better ensure that NHTSA has the clearest possible understanding of the effects of the decision being made, as opposed to the effects of many things that will be occurring simultaneously. All estimates of effects of the different regulatory alternatives presented in this section are thus relative to the No-Action Alternative.

GM stated that it believed the proposed model years 2030–2032 HDPUV standards were appropriate, and it suggested that NHTSA reconsider the model years 2033–2035 standards at a later time, to determine whether they were still appropriate ''consider[ing] availability, reliability, and cost of zero emissions vehicle fuel and refueling infrastructure, and consider[ing] demand for zero emission vehicles as the Clean Commercial Vehicle tax credits under the Inflation Reduction Act expire.''[1482] NHTSA is setting HDPUV standards through model year 2035 for the reasons discussed in Section VI.A, but agrees that it always has authority to reconsider standards based on new information, as long as statutory lead time requirements are met.

Other information that are relevant to whether HDPUV standards are appropriate could include how much energy we estimate they would conserve; the magnitude of emissions reductions; possible safety effects, if any; and estimated effects on sales and employment. NHTSA agrees with commenters that ''appropriate'' encompasses many different concerns related to energy conservation and that reducing fuel use and emissions are important goals of EPCA/EISA. Simultaneously, NHTSA bears in mind that HDPUV is a much smaller fleet (with much lower total VMT) than passenger cars and light trucks, so while we seek to conserve energy with the HDPUV standards, the effects are inevitably relatively small compared to the effects resulting from CAFE standards.

In terms of energy conservation, Alternative HDPUV14 would conserve the most energy and produce the greatest reduction in fuel expenditure, as shown below:

[1481] 49 U.S.C. 32902(h) clearly states that it applies only to actions taken under subsections (c), (f), and (g) of 49 U.S.C. 32902.

[1482] GM, Docket No. NHTSA–2023–0022–60686, at 7.

Table VI-44: Fuel Consumption under HDPUV Regulatory Alternatives, as Compared to No-Action Alternative (quads, CYs 2022-2050)

Fuel Type	HDPUV4	HDPUV108	HDPUV10	HDPUV14
Gasoline	-0.053	-0.649	-1.067	-2.788
E85	0.000	-0.003	-0.006	-0.013
Diesel	0.000	0.001	0.002	0.004
Electricity	0.017	0.189	0.304	0.841
Total	-0.037	-0.461	-0.768	-1.956

Table VI-45: Lifetime Fuel Expenditure under HDPUV Regulatory Alternatives, as Compared to No-Action Alternative, MYs 2030-2038 ($ in millions, 3% Discount Rate)

Model Year	2030	2031	2032	2033	2034	2035	2036	2037	2038	Total
HDPUV4	-77.3	-21.9	-23.2	-23.9	-24.0	-19.2	-19.0	-69.7	-68.6	-346.7
HDPUV108	65.3	61.5	57.7	-480.3	-472.7	-517.8	-508.5	-499.1	-490.7	-2,784.7
HDPUV10	65.6	60.8	57.0	-922.4	-903.5	-980.9	-963.1	-943.9	-927.9	-5,458.3
HDPUV14	-184.3	-350.9	-344.3	-2,450.5	-2,390.3	-2,520.4	-2,472.9	-2,429.1	-2,374.3	-15,517.0

Table VI-46: Per-vehicle Lifetime Fuel Expenditure under HDPUV Regulatory Alternatives, as Compared to No-Action Alternative ($, 3% Discount Rate)

Model Year	2030	2031	2032	2033	2034	2035	2036	2037	2038
HDPUV4	-75.1	-21.2	-22.4	-23.1	-23.1	-18.3	-17.9	-65.0	-63.1
HDPUV108	63.4	59.7	55.9	-465.4	-455.9	-494.3	-479.5	-465.4	-452.2
HDPUV10	63.7	59.0	55.2	-894.4	-872.1	-937.1	-908.7	-880.9	-855.5
HDPUV14	-178.9	-340.8	-333.6	-2,384.2	-2,313.7	-2,414.1	-2,338.4	-2,271.5	-2,192.9

Assuming that benefits to energy security correlate directly with fuel consumption avoided, Alternative HDPUV14 would also contribute the most to improving U.S. energy security. The discussion about energy security effects of passenger car and light truck standards applies for HDPUVs as well.

In terms of environmental benefits, Alternative HDPUV14 is also estimated to be the most beneficial for most metrics:

Table VI-47: Emissions Effects under HDPUV Regulatory Alternatives, as Compared to No-Action Alternative, in Thousands of Tons Unless Otherwise Noted

	HDPUV4	HDPUV108	HDPUV10	HDPUV14
GHGs				
CO_2 Total (mmt)	**-4.48**	**-55.04**	**-91.00**	**-236.16**
Upstream	-0.38	-4.84	-8.35	-20.47
Tailpipe	-4.10	-50.20	-82.65	-215.70
CH_4 Total	**-5.35**	**-65.16**	**-108.06**	**-279.63**
Upstream	-5.25	-64.17	-106.47	-275.06
Tailpipe	-0.11	-0.99	-1.59	-4.57
N_2O Total	**-0.27**	**-3.01**	**-4.87**	**-13.10**
Upstream	-0.13	-1.58	-2.60	-6.76
Tailpipe	-0.14	-1.43	-2.26	-6.33
Criteria Pollutants				
CO Total	**-9.98**	**-93.25**	**-150.70**	**-430.62**
Upstream	0.07	0.54	0.65	2.50
Tailpipe	-10.04	-93.79	-151.34	-433.13
SO_2 Total	**0.16**	**1.43**	**2.09**	**6.42**
Upstream	0.18	1.66	2.48	7.44
Tailpipe	-0.02	-0.24	-0.39	-1.02
NO_x Total	**-0.38**	**-4.24**	**-7.20**	**-18.80**
Upstream	0.04	-0.28	-0.87	-0.77
Tailpipe	-0.42	-3.97	-6.34	-18.03
PM Total	**-0.07**	**-0.73**	**-1.20**	**-3.29**
Upstream	0.00	-0.01	-0.04	-0.01
Tailpipe	-0.07	-0.72	-1.15	-3.26
VOC Total	**-2.37**	**-25.15**	**-41.30**	**-112.56**
Upstream	-1.15	-14.31	-23.67	-61.45
Tailpipe	-1.23	-10.84	-17.62	-51.11

The criteria pollutant effects demonstrate that increased electrification (which increases faster under more stringent alternatives) reduces vehicle-based emissions while increasing upstream emissions due to increased demand for electricity. SELC commented that ''The significant environmental, public health, and equity impacts of improved fuel [efficiency] must be given substantial weight in setting . . . HDPUV standards.''[1483] NHTSA agrees that these are important effects and weighs them carefully in determining maximum feasible HDPUV standards.

Some other effects are fairly muted, possibly due to the relatively small size of the HDPUV fleet. The safety effects associated with the HDPUV alternatives are extremely small, too small to affect our decision-making in this final rule. Readers may refer to Chapter 8.3.4.5 of the FRIA for specific information. For sales and employment, readers may refer to Chapter 8.3.2.3 of the FRIA for more specific information, but there is very little difference in sales between HDPUV alternatives, less than one percent relative to the No-Action Alternatives. Employment effects are of similar relative magnitude; HDPUV108, HDPUV10, and HDPUV14 all subtract very slightly from the reference baseline employment utilization, as sales declines produce a small decrease in labor utilization that are not offset by technology effects (*i.e.,* that development and deployment of new fuel-efficient technologies increases demand for labor). Estimated safety, sales, and employment effects are thus all too small to be dispositive.

In evaluating whether HDPUV standards are cost-effective, NHTSA could consider different ratios of cost versus the primary benefits of the standards, such as fuel saved and GHG emissions avoided. Table VI–48 and Table VI–49 include a number of informative metrics of the HDPUV alternatives relative to the No-Action Alternative. None of the action alternatives emerges as a clearly

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[1483] SELC, Docket No. NHTSA–2023–0022–60224, at 1.

superior option when evaluated along this dimension. When considering aggregate societal effects, as well as when narrowing the focus to private benefits and costs, HDPUV108 produces the highest benefit-cost ratios, although HDPUV4 is also the most cost-effective under several metrics.

Table VI-48: Cost-Effectiveness Metrics under HDPUV Regulatory Alternatives, as Compared to No-Action Alternative ($2021, 3% Discount Rate)

Ratio	HDPUV4	HDPUV108	HDPUV10	HDPUV14
Total societal benefits to total societal costs (CYs 2022-2050, 2.0% SC-GHG discount rate)	4.78	5	4.95	5.01
Total private benefits to total private costs (CYs 2022-2050)	1.38	2.30	2.25	2.13
Fuel savings to regulatory cost (CYs 2022-2050)	3.36	2.12	2.24	2.43
Sales-weighted per-vehicle fuel savings to regulatory cost (MYs 2030-2035)	3.31	2.62	2.88	2.99
Sales-weighted per-vehicle fuel savings to regulatory cost (MYs 1983-2038)	3.98	2.85	3.12	3.26
Total societal benefits to total regulatory cost (CYs 2022-2050, 2.0% SC-GHG discount rate)	9.36	7.32	7.44	7.88

Table VI-49: Cost-Effectiveness Metrics under HDPUV Regulatory Alternatives, as Compared to No-Action Alternative ($2021, 7% Discount Rate)

Ratio	HDPUV4	HDPUV108	HDPUV10	HDPUV14
Total societal benefits to total societal costs (CYs 2022-2050, 2.0% SC-GHG discount rate)	7.95	8.45	8.28	8.31
Total private benefits to total private costs (CYs 2022-2050)	1.14	2.08	2.01	1.85
Fuel savings to regulatory cost (CYs 2022-2050)	2.77	1.89	2.00	2.13
Sales-weighted per-vehicle fuel savings to regulatory cost (MYs 2030-2035)	2.56	2.02	2.22	2.31
Sales-weighted per-vehicle fuel savings to regulatory cost (MYs 1983-2038)	3.07	2.20	2.40	2.52
Total societal benefits to total regulatory cost (CYs 2022-2050, 2.0% SC-GHG discount rate)	14.31	11.98	12.05	12.57

Because NHTSA considers multiple discount rates in its analysis, and because analysis also includes multiple values for the SC–GHG, we also estimate the following cumulative values for each regulatory alternative:

Table VI-50: Summary of Cumulative Benefits and Costs for CY 2022-2050 (2021$ Billions), by Alternative, SC-GHG Value, and DR

Alternative	3% Discount Rate			7% Discount Rate		
	Costs	Benefits	Net Benefits	Costs	Benefits	Net Benefits
SC-GHG discounted at 2.5 percent						
HDPUV4	0.24	0.77	0.53	0.12	0.63	0.51
HDPUV108	3.40	12.64	9.24	1.58	8.99	7.41
HDPUV10	5.62	20.56	14.94	2.66	14.78	12.12
HDPUV14	13.77	50.05	36.28	6.74	37.13	30.39
SC-GHG discounted at 2 percent						
HDPUV4	0.24	1.13	0.89	0.12	0.99	0.87
HDPUV108	3.40	17.03	13.62	1.58	13.38	11.80
HDPUV10	5.62	27.82	22.20	2.66	22.04	19.37
HDPUV14	13.77	68.92	55.15	6.74	56.00	49.26
SC-GHG discounted at 1.5 percent						
HDPUV4	0.24	1.80	1.57	0.12	1.67	1.55
HDPUV108	3.40	25.31	21.91	1.58	21.66	20.08
HDPUV10	5.62	41.52	35.90	2.66	35.74	33.08
HDPUV14	13.77	104.52	90.75	6.74	91.60	84.86

E.O. 12866 and Circular A–4 direct agencies to consider maximizing net benefits in rulemakings whenever possible and consistent with applicable law. Because it can inform NHTSA's consideration of the statutory factors and because it is directed by E.O. 12866 and OMB guidance, NHTSA does evaluate and consider net benefits associated with different potential future HDPUV standards. As Table VI–50 shows, our analysis suggests that HDPUV14 produces the largest net benefits, although we note that the step from both HDPUV10 and HDPUV108 to HDPUV14 results in a substantial jump in total costs.

Our analysis also suggests that all alternatives will result in fuel savings for consumers, and that all alternatives will be cost-effective under nearly every listed metric of comparison and at either discount rate. Overall, avoided climate damages are lower and with each alternative the ratio of cost to benefits for this metric decreases due to increased cost and diminishing climate benefits. As discussed earlier, the HDPUV fleet is a smaller fleet compared to passenger cars and light trucks, and so for a manufacturer to meet standards that are more or less stringent, they must transition a relatively larger portion of that smaller fleet to new technologies. Thus, under some comparisons, HDPUV108 appears the most cost-effective; under others, HDPUV4 appears the most cost-effective. ZETA commented that NHTSA should finalize HDPUV14 as "a feasible and optimal way to cost-effectively improve fleet fuel efficiency and reduce petroleum consumption," because it would maximize fuel savings while providing regulatory certainty to the supply chain.[1484] ICCT commented that costs were likely lower for many HDPUV technologies than NHTSA had modeled, and stated that many gasoline and diesel-efficiency improving technologies have yet to be broadly implemented among HDPUVs.[1485] ACEEE argued that the IRA would hasten learning cost reductions for electric HDPUVs and thus more stringent final standards would be cost-effective if these cost reductions were reflected in NHTSA's analysis.[1486] NHTSA believes that the costs for HDPUV technologies, including BEVs, are based on the best information available to the agency at the present time, and thus are reasonable and accurate for the rulemaking time frame. While HDPUV14 may maximize fuel savings, NHTSA's information presented in the tables above does not support ZETA's assertion that it is the most cost-effective by all metrics.

As discussed above for passenger car and light truck standards, while maximizing net benefits is a valid decision criterion for choosing among alternatives, provided that appropriate consideration is given to impacts that cannot be monetized, it is not the only reasonable decision perspective. We recognize that what we include in our cost-benefit analysis affects our estimates of net benefits. We also note that important benefits cannot be monetized—including the full health and welfare benefits of reducing climate and other pollution, which means that the benefits estimates are underestimates. Thus, given the uncertainties associated with many aspects of this analysis, NHTSA does not rely solely on net benefit maximization, and instead considers it as one piece of information that contributes to how we balance the

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[1484] ZETA, Docket No. NHTSA–2023–0022–60508, at 28.

[1485] ICCT, Docket No. NHTSA–2023–0022–54064, at 25.

[1486] ACEEE, Docket No. NHTSA–2023–0022–60684, at 8.

statutory factors, in our discretionary judgment.

In evaluating whether HDPUV standards are technologically feasible, NHTSA could consider whether the standards represented by the different regulatory alternatives could be met using technology expected to be available in the rulemaking time frame.

On the one hand, the HDPUV analysis employs technologies that we expect will be available, and our analysis suggests widespread compliance with all regulatory alternatives, which might initially suggest that technological feasibility is not at issue for this final rule. At the industry level, technology penetration rates estimated to meet the different regulatory alternatives in the different MYs would be as follows:

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Table VI-51: Estimated Application of Selected Technologies, Percent of HDPUV Fleet

Technology	Alternative	2022	2030	2031	2032	2033	2034	2035	2036	2037	2038
Technology Application Levels in the No-Action Alternative											
Advanced Engines	No Action	43	46	24	24	24	24	24	24	24	23
Strong Hybrid (all types)	No Action	0	27	38	38	38	38	38	38	38	37
PHEV (all types)	No Action	0	0	0	0	0	0	0	0	0	0
BEV (all types)	No Action	0	27	37	37	38	38	38	38	38	40
Modeled Technology Application Levels Incremental to the No-Action Alternative											
Advanced Engines	HDPUV4	-	0	0	0	0	0	0	0	0	0
Strong Hybrid (all types)	HDPUV4	-	0	0	0	0	0	0	0	0	0
PHEV (all types)	HDPUV4	-	0	0	0	0	0	0	0	0	0
BEV (all types)	HDPUV4	-	0	0	0	0	0	0	0	0	0
Advanced Engines	HDPUV108	-	0	0	0	-3	-3	-3	-3	-3	-3
Strong Hybrid (all types)	HDPUV108	-	0	0	0	-1	-1	-1	-1	-1	-1
PHEV (all types)	HDPUV108	-	0	0	0	+4	+4	+4	+4	+4	+4
BEV (all types)	HDPUV108	-	0	0	0	0	0	0	0	0	0
Advanced Engines	HDPUV10	-	0	0	0	-5	-5	-6	-6	-6	-6
Strong Hybrid (all types)	HDPUV10	-	0	0	0	-1	-1	-1	-1	-1	-1
PHEV (all types)	HDPUV10	-	0	0	0	+6	+6	+6	+6	+6	+6
BEV (all types)	HDPUV10	-	0	0	0	+1	+1	+1	+1	+1	+1
Advanced Engines	HDPUV14	-	-1	-2	-2	-12	-12	-13	-13	-13	-13
Strong Hybrid (all types)	HDPUV14	-	0	0	0	-5	-5	-5	-5	-5	-5
PHEV (all types)	HDPUV14	-	0	0	0	+11	+11	+12	+12	+12	+12
BEV (all types)	HDPUV14	-	+1	+2	+2	+6	+6	+6	+6	+6	+6

Advanced Engines: Combined penetration of advanced cylinder deactivation, advanced turbo and diesel engines[1487]

As Table VI–51[1487] shows, it is immediately clear that most technology application between now and model year 2038 would be occurring as a result of reference baseline efforts and would not be an effect of new NHTSA standards. Under the reference baseline, as early as model year 2033, nearly 80 percent of the fleet would be electrified (including SHEV, PHEV, and BEV). As mentioned above, Valero argued that the proposed standards relied entirely on changes in the reference baseline, and that the proposed standards themselves contributed nothing (*i.e.,* that the reference baseline assumptions are excessive). NHTSA agrees that the reference baseline technology penetration rates were high for the proposal and remain high for the final rule. Nevertheless, NHTSA believes that these reference baseline technology penetration rates, while high, are feasible and the best available projection of reference case technology deployment in this time frame, given projected trends for HD vans in particular (vans are roughly 40 percent of the HDPUV fleet during the rulemaking time frame). Due to the relatively small number of models in the HDPUV fleet as compared to the passenger car and light truck fleets, just a few models becoming electrified can have large effects in terms of the overall fleet. NHTSA also recognizes that these reference baseline technology penetration rates result from our assumptions about battery costs and available tax credits, among other things.[1488] Some commenters argued that NHTSA was itself obligated to prove that sufficient U.S.-derived critical minerals, sufficient vehicle charging infrastructure, and sufficient consumer demand for BEV HDPUVs would exist by the rulemaking time frame, in order for NHTSA to establish that the HDPUV standards were technologically feasible. NHTSA continues to believe that it is reasonable to assume that critical minerals and charging infrastructure will be sufficient to support BEV volume assumptions in the analysis by the rulemaking time frame. NHTSA bases this belief on the U.S. government sources cited in TSD Chapter 6.2.4 and discussed above in Section VI.A.5.a(4)(d) of this preamble. NHTSA agrees with the conclusion of these sources that the BIL will contribute significantly toward resolving these concerns by the rulemaking time frame. With regard to consumer demand for BEVs, NHTSA believes that it is evident from sales that consumer demand continues to grow, especially for the van segment of the HDPUV fleet, and that the IRA tax credits will continue to encourage consumer demand as battery costs continue to decrease and cost parity is eventually reached.

Against the backdrop of the reference baseline, HDPUV4 would require no additional technology at all, on average, which explains why the per-vehicle fuel cost savings associated is low. HDPUV108 could be met with an additional 4.4 percent increase in PHEVs in MY2038. HDPUV10 could be met with an additional 6 percent increase in PHEVs, and very slight increases in BEVs in the later years rulemaking time frame. HDPUV14 could be met with an additional 11–12 percent increase in PHEVs, an additional 6 percent increase in BEVs, and a 13 percent decrease in advanced engines by model year 2038.

As in the analysis for passenger cars and light trucks, however, NHTSA finds manufacturer-level results to be particularly informative for this analysis. Of the five manufacturers modeled for HDPUV, Mercedes-Benz, Nissan, and Stellantis would be able to meet all regulatory alternatives with reference baseline technologies—only Ford and GM show any activity in response to any of the regulatory alternatives. HDPUV14 pushes Ford to increase volumes of PHEVs and BEVs. Alternatives more stringent than HDPUV4 result in higher penetration rates of PHEVs and BEVs for GM, with most change coming from PHEVs, especially for HDPUV108 and HDPUV10.

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[1487] The list of these engines is discussed in TSD Chapter 3.1.

[1488] All EVs have zero emissions and are asisgned the fuel consumption test group result to a value of zero gallons per 100 miles per 49 CFR 535.6(a)(3)(iii).

Table VI-52: Technology Availability by Manufacturer for Selected Model Years by Alternative

	No Action		HDPUV4	HDPUV108	HDPUV10	HDPUV14
Model Year:	2029	2038	2038	2038	2038	2038
Ford						
Advanced Engines	66%	32%	31%	32%	29%	17%
Strong Hybrid (all types)	29%	28%	28%	28%	28%	27%
PHEV (all types)	0%	0%	0%	0%	0%	3%
BEV (all types)	6%	40%	41%	40%	43%	53%
Advanced AERO	100%	100%	100%	100%	100%	100%
Advanced MR	0%	0%	0%	0%	0%	0%
GM						
Advanced Engines	51%	31%	31%	22%	17%	9%
Strong Hybrid (all types)	45%	45%	45%	42%	42%	30%
PHEV (all types)	0%	0%	0%	12%	17%	34%
BEV (all types)	5%	24%	24%	24%	24%	27%
Advanced AERO	100%	100%	100%	100%	100%	100%
Advanced MR	0%	0%	0%	0%	0%	0%
Mercedes-Benz						
Advanced Engines	0%	0%	0%	0%	0%	0%
Strong Hybrid (all types)	45%	11%	11%	11%	11%	10%
PHEV (all types)	0%	0%	0%	0%	0%	0%
BEV (all types)	55%	89%	89%	89%	89%	90%
Advanced AERO	100%	100%	100%	100%	100%	100%
Advanced MR	0%	0%	0%	0%	0%	0%
Nissan						
Advanced Engines	45%	0%	0%	0%	0%	0%
Strong Hybrid (all types)	0%	0%	0%	0%	0%	0%
PHEV (all types)	0%	0%	0%	0%	0%	0%
BEV (all types)	55%	100%	100%	100%	100%	100%
Advanced AERO	100%	100%	100%	100%	100%	100%
Advanced MR	0%	0%	0%	0%	0%	0%
Stellantis						
Advanced Engines	94%	1%	0%	0%	1%	0%
Strong Hybrid (all types)	0%	47%	47%	47%	47%	47%
PHEV (all types)	0%	1%	1%	1%	1%	1%
BEV (all types)	6%	52%	52%	52%	52%	52%
Advanced AERO	100%	100%	100%	100%	100%	100%
Advanced MR	0%	0%	0%	0%	0%	0%

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Again, it is clear that a great deal of technology application is expected in response to the reference baseline, as evidenced by the fact that technology penetration rates for most manufacturers do not change between alternatives. For example, Stellantis is assumed to go from 0 percent strong hybrids in its

HDPUV fleet in model year 2030 to 47 percent strong hybrids by model year 2038 under each regulatory alternative, which means that the regulatory alternatives are not influencing that decision—because if they were, we would see technology differences between the alternatives. Ford and GM show more responsiveness to the alternatives, especially for stringencies beyond HPDUV4. Technology solutions for Ford are similar for HDPUV108 and HDPUV10, up to HDPUV14, at which point a larger portion of the fleet is converted to BEVs to meet the more stringent standards. GM shows more movement across alternatives, but NHTSA continues to suspect that this may be an artifact of our relatively smaller data for the HDPUV fleet. It is very possible that the apparent increase in PHEVs and BEVs and decrease in advanced engine rates for GM could be due to the fact that technologies in the reference baseline fleet are based on Phase 1 standards and (for purposes of the analysis) manufacturers have not started adopting technologies to meet Phase 2 standards.

We note also that NHTSA is allowed to consider banked overcompliance credits for the HDPUV fleet,[1489] as well as the full fuel efficiency of AFVs like BEVs and PHEVs.[1490] Combined with the fact that BEVs and the electric operation of PHEVs are granted 0 gal/100 miles fuel consumption for compliance purposes, our analysis shows that even with one redesign we see large improvements in the fleet even at low volumes, because manufacturers have relatively fewer models, and lower volumes of those models, as compared to the passenger car/light truck fleet—so ‘‘20 percent increase in BEVs’’ could be a single model being redesigned in a given model year. While the analysis does show higher stringency alternatives as being slightly more challenging to GM in particular, nothing in EPCA/EISA suggests that for HDPUV standards, ‘‘technological feasibility’’ should be interpreted as ‘‘every manufacturer meets the standards without applying additional technology.’’ Based on the information before us, NHTSA cannot conclude that technological feasibility is necessarily a barrier to choosing any of regulatory alternatives considered in this final rule.

Valero commented that the proposed standards were not technologically feasible because NHTSA was ‘‘killing diesel engines’’ by not assuming that CI engines could be paired with SHEV or PHEV technology in our analysis. In response, we reiterate that our standards are performance-based, and that they do not serve as an edict to industry about how our standards must be met. NHTSA's technology tree did not simulate CI engines being paired with SHEV or PHEV technology, but that in no way precludes manufacturers from using that technology, nor does NHTSA mean to say that NHTSA does not believe that CI engines could be used with SHEV or PHEV systems. Instead, this technology decision was a simplifying assumption, as discussed in the TSD, where NHTSA decides how to represent a technology being applied but always recognizes that there will likely be a diverse representation of that technology in the actual vehicle fleet. Other similar simplifying assumptions include assuming future SHEVs will only be of the P2 variety in the future, because that was the specific technology form used to represent the technology in our analysis, when of course SHEV technology may be more diverse than that, or that all forced induction engines will only use exhaust-based turbo systems, with no superchargers. NHTSA therefore disagrees with Valero that the CI standard compels the elimination of CI engines and disagrees that the CI standard somehow prohibits SHEV and PHEV powertrains from using CI engines. The technology path that NHTSA shows to compliance is simply *a* path, not *the* path, as NHTSA endeavors to emphasize. NHTSA also disagrees that the final standards present a ‘‘major question’’ as Valero suggested, because (1) they do not mandate specific technologies, (2) they are incremental increases in stringency based on the agency's determination of maximum feasible fuel efficiency standards, consistent with the agency's direction in EPCA/EISA, and (3) even if the final standards do assume electrification in the analysis in response to the standards, 49 U.S.C. 32902(h) does not cover decisions made under 32902(k).

The information presented thus far suggests that HDPUV14 would result in the best outcomes for energy conservation, including fuel consumption and fuel expenditure reduced, energy security, climate effects, and most criteria pollutant effects; that it would produce the largest net benefits, and that it is likely achievable with not much more technology than would be applied in the reference baseline regardless of new HDPUV standards from NHTSA; even if it would not necessarily be the most cost-effective, would result in the highest overall costs, and does not provide the largest consumer net benefits. Even if HDPUV14 would maximize energy conservation, for purposes of this final rule, however, NHTSA concludes that some conservatism may still be appropriate.

As in the proposal, there are several reasons for this conservatism in this final rule. First, NHTSA recognizes that standards have remained stable for this segment for many years, since 2016. While on the one hand, that may mean that the segment has room for improvement, or at least for standards to catch up to where the fleet is, NHTSA is also mindful that the sudden imposition of stringency where there was previously little may require some adjustment time, especially with technologies like BEVs and PHEVs that have not been in mass production in the HDPUV space. Second, NHTSA acknowledges that our available data in this segment may be less complete than our data for passenger cars and light trucks. Compared to the CAFE program's robust data submission requirements, manufacturers submit many fewer data elements in the HD program, and the program is newer, so we have many fewer years of historical data. If NHTSA's technology or vehicle make/model assumptions in the reference baseline lags on road production, then our estimated manufacturer responses to potential new HDPUV standards could lack realism in important ways, particularly given the relatively smaller fleet and fewer numbers of make/models across which manufacturers can spread technology improvements in response to standards. Although NHTSA also relies on manufacturer media publications for announcements of new vehicles and technologies, we are considerate of how those will be produced in large quantities and if they can be considered by other competitors due to intellectual property issues and availability.

Third, again perhaps because of the relatively smaller fleet and fewer numbers of make/models, the sensitivity analysis for HDPUVs strongly suggests that uncertainty in the input assumptions can have significant effects on outcomes. As with any analysis of sufficient complexity, there are a number of critical assumptions here that introduce uncertainty about manufacturer compliance pathways, consumer responses to fuel efficiency improvements and higher vehicle prices, and future valuations of the consequences from higher HDPUV standards. Recognizing that uncertainty, NHTSA also conducted 50 sensitivity

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[1489] See Manufacturers tab in the CAFE Model Input file market_data_HDPUV_ref.xlsx for HDPUV banked credits.

[1490] 49 CFR 535.6(a)(3)(iii).

analysis runs for the HDPUV fleet analysis.[1491] The entire sensitivity analysis is presented in Chapter 9 of the FRIA, demonstrating the effect that different assumptions would have on the costs and benefits associated with the different regulatory alternatives. While NHTSA considers dozens of sensitivity cases to measure the influence of specific parametric assumptions and model relationships, only a small number of them demonstrate meaningful impacts to net benefits under the different alternatives.

The results of the sensitivity analyses for HDPUVs are different from the sensitivity analysis results for passenger cars and light trucks. Generally speaking, for HDPUVs, varying the inputs seems either to make no difference at all, or to make a fairly major difference. As suggested above, NHTSA interprets this as likely resulting from the relatively smaller size and ''blockiness'' of the HDPUV fleet: there are simply fewer vehicles, and fewer models, so variation in input parameters may cause notable moves in tranches of the fleet that are large enough (as a portion of the total HDPUV fleet) to produce meaningful effects on the modeling results.

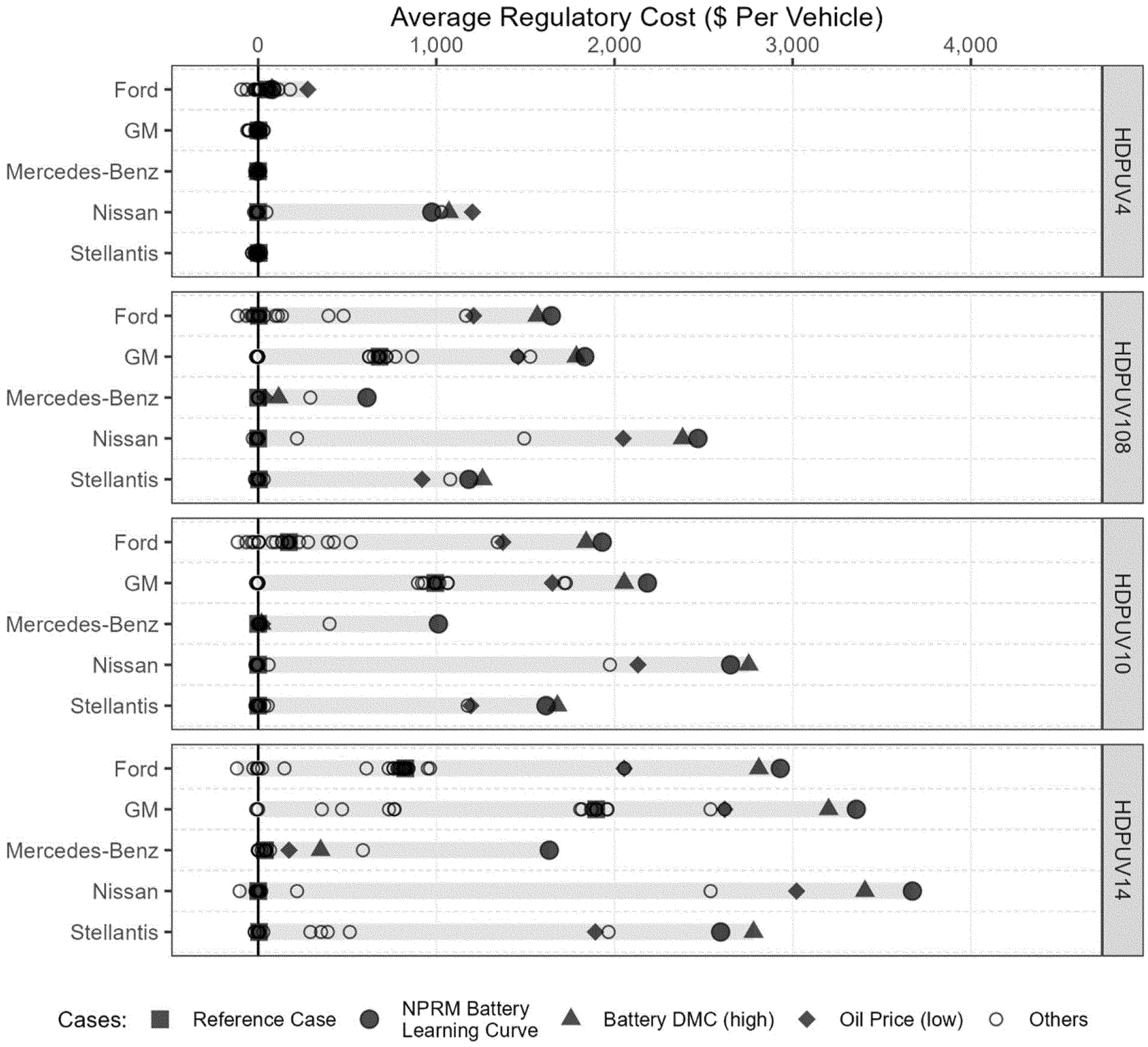

Figure VI-30: Effects of Sensitivity Runs on Per-Vehicle Costs in MY 2038 (2021$), HDPUV Fleet

Figure VI–30 shows the magnitude of variation in sensitivity cases on per-vehicle costs for the HDPUV fleet. Each point in the figure represents the average per-vehicle cost for a given manufacturer, in a given alternative, for

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[1491] In response to IPI's suggestion that NHTSA should conduct Monte Carlo analysis rather than sensitivity analysis, NHTSA was unable to develop Monte Carlo capabilities in time for this final rule but will continue to develop our capabilities for subsequent rounds of rulemaking. Meanwhile, we continue to believe that sensitivity cases are illuminating and appropriate for consideration in determining the final standards.

one sensitivity case; each row includes one point for each of the 50 sensitivity cases. While most sensitivity cases are represented by open circles, some specific cases of interest are highlighted with different shapes. For most manufacturers and alternatives, the sensitivity results are clustered around the reference baseline (represented by a square) and may overlap with other sensitivity results. Some cases, especially involving assumptions about higher costs of electrification or lower fuel prices, produce significant increases in per-vehicle cost relative to the Reference baseline. Table VI–53 shows estimated per-vehicle costs by HDPUV manufacturer, by regulatory alternative, for the Reference baseline (the central analysis) and several selected influential sensitivity runs.

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Table VI-53: Effects of Selected Sensitivity Runs on Per-Vehicle Costs in MY 2038 (2021$), HDPUV Fleet

Manufacturer	Regulatory Alternative	Reference baseline	Sensitivity Runs		
			Oil Price (low)	Battery DMC (high)	NPRM Battery Learning Curve
Ford	No Action	714	-465	299	214
	HDPUV4	+48	+279	+78	+77
	HDPUV108	+4	+1,209	+1,567	+1,646
	HDPUV10	+173	+1,373	+1,841	+1,931
	HDPUV14	+826	+2,054	+2,810	+2,931
GM	No Action	-828	-1,541	-960	-1,129
	HDPUV4	+2	0	0	0
	HDPUV108	+682	+1,460	+1,786	+1,834
	HDPUV10	+995	+1,651	+2,055	+2,185
	HDPUV14	+1,898	+2,618	+3,202	+3,357
Mercedes-Benz	No Action	211	-509	966	-345
	HDPUV4	0	-3	-3	-2
	HDPUV108	0	+38	+115	+611
	HDPUV10	0	+25	+19	+1,012
	HDPUV14	+38	+173	+351	+1,634
Nissan	No Action	4,719	1,092	1,843	1,883
	HDPUV4	0	+1,203	+1,071	+975
	HDPUV108	+1	+2,049	+2,382	+2,468
	HDPUV10	+1	+2,132	+2,753	+2,652
	HDPUV14	+1	+3,022	+3,406	+3,672
Stellantis	No Action	-199	-2,201	-1,550	-1,720
	HDPUV4	+3	0	0	+1
	HDPUV108	+5	+920	+1,259	+1,183
	HDPUV10	+1	+1,194	+1,680	+1,616
	HDPUV14	+5	+1,893	+2,781	+2,596
Industry Average	No Action	51	-1,197	-498	-666
	HDPUV4	+20	+130	+50	+48
	HDPUV108	+226	+1,203	+1,537	+1,582
	HDPUV10	+394	+1,395	+1,834	+1,926
	HDPUV14	+946	+2,161	+2,867	+2,966

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In this table, ''Oil Price (low)'' assumes EIA's AEO 2023 low oil price side case; ''Battery DMC (high)'' increases battery direct manufacturing costs 25 percent above Reference baseline levels; and ''NPRM Battery Learning Curve'' retains the battery learning curve from NHTSA's NPRM. Dollar values for all action alternatives are incremental to the No-Action alternative. If they are negative, that means that the compliance solution for that action alternative reduces cost relative to no action in a given model run.[1492] These particular sensitivity runs were selected because they had the largest effect on costs of the alternatives considered, and cost is of primary interest to NHTSA given industry's stated need to retain all available capital for use in making the BEV transition.. The final standards for HDPUVs will result in an industry-wide FE improvement of approximately 25 percent in the rulemaking time frame of only 6 years. With the vehicles in this segment having the same if not longer redesign cycle time, our analysis shows that any change to these inputs could have a dramatic impact on the manufacturers. As shown in Table VI–53 above, the industry average incremental cost for HDPUV108 is $226, but that increases to roughly $1,200 to over $1,500 with the change to an input that could be due to any number of global circumstances.

Looking beyond HDPUV108, each of these sensitivity runs illustrate that per-vehicle costs for nearly every manufacturer to comply with HDPUV10 and HDPUV14 could be significantly higher under any of these cases. Looking at the industry average results, each of the three sensitivity runs presented here could bring per-vehicle costs to nearly $3,000 per vehicle in model year 2038 under HDPUV14, and nearly $2,000 per vehicle under HDPUV10. While the effects of these assumptions are slightly less dramatic than in the NPRM analysis, they are still significant increases in costs for an industry grappling with a major technological transition. For nearly every manufacturer, the jump in cost from HDPUV4 to HDPUV108 is meaningful under each sensitivity run shown, and the jump from HDPUV108 to HDPUV10 and certainly to HDPUV14 under each of the sensitivity runs shown would be greater than NHTSA would likely conclude was appropriate for this segment. The uncertainty demonstrated in these estimates aligns with comments NHTSA received on the NPRM and NHTSA believes it is relevant to our consideration of maximum feasible HDPUV standards. The Alliance commented that if NHTSA set standards through model year 2035, annual stringency increases in model years 2030–2032 should be 10% per year, and model years 2033–2035 should be 4% per year, in recognition of ''market and technology uncertainty.''[1493] Alternatively, the Alliance stated that stringency increases could be 7% per year, each year, for model years 2030–2035.[1494]

NHTSA agrees that uncertainty exists, and it matters for this segment and the effects that new HDPUV standards would have on the affordability of these vehicles and the capital available for manufacturers for making the BEV transition. The nature of this fleet—smaller, with fewer models—and the nature of the technologies that this fleet will be applying leading up to and during the rulemaking time frame, means that the analysis is very sensitive to changes in inputs, and the inputs are admittedly uncertain. If the uncertainty causes NHTSA to set standards higher than they would otherwise have been, and industry is unable to meet the standards, the resources they would have to expend on civil penalties (which can potentially be much higher for HDPUVs than for passenger cars and light truck) would be diverted from their investments in the technological transition, and the estimated benefits would not come to pass anyway. To provide some margin for that uncertainty given the technological transition that this segment is trying to make, NHTSA believes that some conservatism is reasonable and appropriate for this round of standards. However, the further conservatism that the Alliance and other commenters request—4 percent standards for model years 2033–2035, or 7 percent standards for model years 2030–2035—would have NHTSA setting standards below the point of maximum feasibility. In response to this comment, NHTSA conducted some initial analysis of these suggested rates of increase and this exploratory analysis indicated technology choices, and hence regulatory costs, were very similar to those of HDPUV4. Based on that initial analysis, NHTSA concluded that the effects of these suggested rates of increase would have fallen close enough to HDPUV4 that a full examination would not have provided much additional information beyond what including HDPUV4 in the analysis already includes.

We also note, that because NHTSA does consider BEV technologies in the HDPUV analysis, and because our current regulations assign BEVs a fuel consumption value for compliance purposes of 0 gal/100 miles, this significantly influences our modeling results. This is an artifact of the mathematics of averaging, where including a ''0'' value in the calculation effectively reduces other values by as much as 50 percent (depending on sample size) and is exaggerated when BEV-only manufacturers are considered in industry-average calculations. This effect creates the appearance of overcompliance at the industry level. As for the analysis for passenger cars and light trucks, examining individual manufacturer results can be more informative, and Chapter 8.3 of the FRIA shows that non-BEV-only manufacturers are more challenged by, for example, HDPUV14, although overcompliance is still evident in many model years. This underscores the effect of BEVs on compliance, particularly when their fuel consumption is counted as 0 even though their energy consumption is non-zero. It also indirectly underscores the effect of the 32902(h) restrictions on NHTSA's decision-making for passenger car and light truck standard stringency, which does not apply in the HDPUV context. While NHTSA did not propose to change this value and is not changing it in this final rule, we are aware that it adds to the appearance of overcompliance in NHTSA's analysis, and this is another potential reason to be conservative in our final rule.

Based on the information in the record and consideration of the comments received, NHTSA therefore concludes that HDPUV108 represents the maximum feasible standards for HDPUVs in the model years 2030 to 2035 time frame. While HDPUV14 could potentially save more fuel and reduce emissions further, it is less cost-effective than HDPUV108 by every metric that NHTSA considered, and the longer redesign cycles in this segment make NHTSA cautious of finalizing HDPUV14. Moreover, the effects of uncertainty for our analytical inputs are significant in this analysis, as discussed, and NHTSA believes some conservatism is appropriate for this rulemaking time frame. Both HDPUV10 and HDPUV108 will encourage technology application for some manufacturers while functioning as a backstop for the others, and they remain net beneficial for consumers. However, in a final consideration of coordination between the HDPUV GHG rules recently finalized by EPA and these fuel consumption standards, NHTSA believes HDPUV108 provides a better approach.

The HDPUV108 final rule will serve to re-align the two rules after being offset by statutory differences in lead time and standard years. HDPUV108

[1492] This occurs in some instances where incremental technology additions are less expensive than the value of any technology removed. For example, the engine and transmission component cost differences in converting from an advanced diesel to a gasoline turbo engine PHEV could produce negative net technology cost.

[1493] The Alliance, Docket No. NHTSA–2023–0022–60652, Appendix F, at 63.

[1494] *Id.*

will best harmonize with EPA's recently finalized standards, realigning with EPA by model year 2034 and only slightly surpassing them in model year 2035 (assuming EPA does not later change its standards for the model years 2033–2035 time frame). The need for harmonization was frequently cited in comments, and NHTSA has sought to the best of its statutory ability to harmonize with EPA's broader authority under the Clean Air Act.

Based on all of the reasons discussed above, NHTSA is finalizing HDPUV108 for HDPUVs.

3. Severability

For the reasons described above, NHTSA believes that its authority to establish CAFE and HDPUV standards for the various fleets described is well-supported in law and practice and should be upheld in any legal challenge. NHTSA also believes that its exercise of its authority reflects sound policy.

However, in the event that any portion of the final rule is declared invalid, NHTSA intends that the various aspects of the final rule be severable, and specifically, that each standard and each year of each standard is severable, as well as the various compliance changes discussed in the following section of this preamble. NYU IPI commented that NHTSA should provide further detail on why NHTSA believes that the standards are severable.[1495] Furthermore, they identified a specific area of the analysis and state, ''Because changing manufacturing processes for one product class or model year could affect those processes for another, NHTSA should explain why these technical processes are sufficiently independent that individual standards for each year could be applied separately.''I. In response, EPCA/EISA is clear that standards are to be prescribed separately for each fleet, for each model year. 49 U.S.C. 32902(b) states expressly that DOT (by delegation, NHTSA) must set separate standards for passenger automobiles (passenger cars) in each model year, non-passenger automobiles (light trucks) in each model year, and work trucks (HDPUVs) in accordance with 32902(k), which directs that standards be set in tranches of 3 model years at a time. When NHTSA sets these standards, it does so by publishing curve coefficients in the **Federal Register**, to be incorporated into the Code of Federal Regulations. The curve coefficients are incorporated into the same table, but they are clearly distinguishable for each year. NHTSA establishes several model years of standards at a time in order to provide improved regulatory certainty for industry, but standards for one year can still be met by any given fleet even if standards for a prior or subsequent year suddenly do not exist. We agree with IPI in that manufacturers do share components between vehicles and apply these components for different vehicle classes at different model years; however, we do acknowledge that manufacturers do not implement technologies all at once across their fleets within a given model year or subsequent model year. NHTSA does not set CAFE or FE standards at the vehicle level, but instead at the individual fleet levels. And so, adoption of technologies for meeting the standards are allowed in a cadence that reflects manufacturers capability to implement a reasonable time for PCs, LTs and HDPUVs. These assumptions for sharing of components between vehicles are considered as part of our analysis that considers refreshes/redesigns schedules that manufacturers adhere to. We discuss vehicle refreshes/redesigns cadences and other lead time assumptions in TSD Chapter 2 and in Section III.D of this preamble. The modeling captures decisions that manufacturers make in the real world that will happen regardless of whether NHTSA is considering one year of standards or five. Manufacturers will still only refresh or redesign a portion of their fleet in any given model year and even though our analysis shows one pathway to compliance, manufacturers make the ultimate decisions about which technologies to apply to which vehicles in a particular model year, also considering factors unrelated to fuel economy. Manufacturer comments may discuss the relative difficulty of complying with one standard or another, but since the inception of the program, compliance with each standard has been separately required.

Any of the standards could be implemented independently if any of the other standards were struck down, and NHTSA firmly believes that it would be in the best interests of the nation as a whole for the standards to be applicable in order to support EPCA's overarching purpose of energy conservation. Each standard is justified independently on both legal and policy grounds and could be implemented effectively by NHTSA.

VII. Compliance and Enforcement

NHTSA is finalizing changes to its enforcement programs for light-duty vehicles in the CAFE program as well as for HDPUVs in the Heavy-Duty National Program. These changes include: (1) eliminating AC and off-cycle (OC) fuel consumption improvement values (FCIVs) for BEVs in the CAFE program; (2) adding a utility factor to the calculation of FCIVs for PHEVs; (3) phasing out the OC program for all vehicles in the CAFE program by model year 2033; (4) eliminating the 5-cycle and alternative approval pathways for OC FCIVs in the CAFE program; (5) adding additional deadlines for the alternative approval process for model years 2025–2026 for the CAFE program; (6) eliminating OC FCIVs for HDPUVs for model year 2030 and beyond; and (7) making an assortment of minor technical amendments, including technical amendments to the regulations pertaining to advanced technology credits and clarifying amendments to definitions in 49 part 523. To provide context for these changes, this section first provides an overview of NHTSA's enforcement programs. The section then discusses and addresses the comments received on the NPRM and discusses the changes NHTSA is finalizing with this rule. Finally, this section concludes with a discussion and response to comment on a requested program for EJ credits that NHTSA has decided is not practical to implement at this time, as well as a discussion and response to comments received that are relevant to NHTSA's compliance and enforcement programs for light-duty vehicles and HDPUVs but out of scope of this rulemaking.

A. Background

NHTSA has separate enforcement programs for light-duty vehicles in the CAFE program and heavy-duty vehicles in the Heavy-Duty National program. NHTSA's CAFE enforcement program is largely established by EPCA, as amended by EISA, and is very prescriptive regarding enforcement. EPCA and EISA also clearly specify a number of flexibilities and incentives that are available to manufacturers to help them comply with the CAFE standards. EISA also provides DOT and NHTSA with the authority to regulate heavy-duty vehicles, and NHTSA structured the enforcement program for HDPUVs to be similar to its CAFE enforcement program.

The light-duty CAFE program includes all vehicles with a Gross Vehicle Weight Rating (GVWR) of 8,500 pounds or less as well as vehicles between 8,501 and 10,000 pounds that are classified as medium-duty passenger vehicles (MDPVs). As prescribed by 49 U.S.C. 32901(a)(19)(B) and defined in 40

[1495] IPI, Docket No. NHTSA–2023–0022–60485, at 32–33.

CFR 86.1803–01,[1496] an MDPV means any heavy-duty vehicle with a GVWR of less than 10,000 pounds that is designed primarily for the transportation of persons and generally subject to requirements that apply for light-duty trucks.[1497] [1498] The MDHD Program includes all vehicles 8,501 pounds and up, and the engines that power them, except for MDPVs, which are covered under the CAFE program.

NHTSA's authority to regulate heavy-duty vehicles under EISA directs NHTSA to establish fuel efficiency standards for commercial medium- and heavy-duty on-highway vehicles and work trucks.[1499] [1500] Under this authority, NHTSA has developed standards for three regulatory categories of heavy-duty vehicles: combination tractors; HDPUVs; and vocational vehicles. HDPUVs include heavy-duty vehicles with a GVWR between 8,501 pounds and 14,000 pounds (known as Class 2b through 3 vehicles) manufactured as complete vehicles by a single or final stage manufacturer or manufactured as incomplete vehicles as designated by a manufacturer.[1501] The majority of these HDPUVs are 3- 4-ton and 1-ton pickup trucks, 12-and 15-passenger vans, and large work vans that are sold by vehicle manufacturers as complete vehicles, with no secondary manufacturer making substantial modifications prior to registration and use. These vehicles can also be sold as cab-complete vehicles (*i.e.,* incomplete vehicles that include complete or nearly complete cabs that are sold to secondary manufacturers).

B. Overview of Enforcement

This subsection is intended to provide a general overview of NHTSA's enforcement of its fuel economy and fuel efficiency standards in order to provide context for the discussion of the changes to these enforcement programs. At a high-level, NHTSA's fuel efficiency and fuel economy enforcement programs encompass how NHTSA determines whether manufacturers comply with standards for each model year, and how manufacturers may use compliance flexibilities and incentives, or alternatively address noncompliance through paying civil penalties. NHTSA's goal in administering these programs is to balance the energy-saving purposes of the authorizing statutes against the benefits of certain flexibilities and incentives. More detailed explanations of NHTSA's enforcement programs have also been included in recent rulemaking documents.[1502] [1503]

1. Light Duty CAFE Program

As mentioned above, there are three primary components to NHTSA's compliance program: (1) determining compliance; (2) using flexibilities and incentives; and (3) paying civil penalties for shortfalls. The following table provides an overview of the CAFE program for light-duty vehicles and MDPVs.

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[1496] As prescribed in 49 U.S.C. 32901(a)(19)(B), an MDPV is ''defined in section 86.1803–01 of title 40, Code of Federal Regulations, as in effect on the date of the enactment of the Ten-in-Ten Fuel Economy Act.''

[1497] 40 CFR 86.1803–01 excludes from the definition of MDPV ''any vehicle which: (1) Is an ''incomplete truck'' as defined in this subpart; or (2) Has a seating capacity of more than 12 persons; or (3) Is designed for more than 9 persons in seating rearward of the driver's seat; or (4) Is equipped with an open cargo area (for example, a pick-up truck box or bed) of 72.0 inches in interior length or more. A covered box not readily accessible from the passenger compartment will be considered an open cargo area for purposes of this definition.''

[1498] See Heavy-duty vehicle definition in 40 CFR 86.1803–01. MDPVs are classified as either passenger automobiles or light trucks depending on whether they meet the critiera to be a non-passenger automobile under 49 CFR 523.5. If the MDPV is classified as a non-passenger automobile, it is a light truck and subject ot the requirements in 49 CFR 533. If the MDPV does not meet the criteria in 49 CFR 523.5 to be a non-passenger automobile, then it is classified as a passenger automobile and subject to the requriements in 49 CFR 531.

[1499] EISA added the following definition to the automobile fuel economy chapter of the U.S. Code: ''commercial medium- and heavy-duty on-highway vehicle'' means an on-highway vehicle with a gross vehicle weight rating of 10,000 pounds or more. 49 U.S.C. 32901(a)(7).

[1500] EISA added the following definition to the automobile fuel economy chapter of the U.S. Code: ''work truck'' means a vehicle that—(A) is rated at between 8,500 and 10,000 pounds gross vehicle weight; and (B) is not a medium-duty passenger vehicle (as defined in section 86.1803–01 of title 40, Code of Federal Regulations, as in effect on the date of the enactment of [EISA]). 49 U.S.C. 32901(a)(19).

[1501] *See* 49 CFR 523.7, 40 CFR 86.1801–12, 40 CFR 86.1819–14, 40 CFR 1037.150.

[1502] For more detailed explanations of CAFE enforcement, *see* 77 FR 62649 (October 15, 2012) and 87 FR 26025 (May 2, 2022).

[1503] For more detailed explanations of heavy-duty pickup trucks and vans fuel efficiency standards and enforcement, *see* 76 FR 57256 (September 15, 2011) and 81 FR 73478 (October 25, 2016).

Table VII-1: Overview of Compliance for CAFE Program

Fleet Performance Requirements			
Component	*Applicable Regulation (Statutory Authority)*	*General Description*	*Finalized Changes in FRM*
Fuel Economy Standards	49 CFR 531.5 and 49 CFR 533.5 (49 U.S.C. 32902)	Standards are footprint-based fleet average standards for each of a manufacturer's fleets (i.e., domestic passenger vehicle, import passenger vehicle, and light truck) and expressed in miles per gallon (mpg). NHTSA sets average fuel economy standards that are the maximum feasible for each fleet for each model year. In setting these standards, NHTSA considers technological feasibility, economic practicability, the effect of other motor vehicle standards of the Government on fuel economy, and the need of the U.S. to conserve energy. NHTSA is precluded from considering the fuel economy of vehicles that operate only on alternative fuels, the portion of operation of a dual fueled vehicle powered by alternative fuel, and the trading, transferring, or availability of credits.	Yes: Amendments to 49 CFR 531.5(c)(2) and 49 CFR 533.5(a) to set standards for MY 2027-2031.
Minimum Domestic Passenger Car Standards	49 CFR 531.5 (49 U.S.C. 32902(b)(4))	Minimum fleet standards for domestically manufactured passenger vehicles.	Yes: Amendments to 49 CFR 531.5(d) to set standards for MY 2027-2031.
Determining Average Fleet Performance			
Component	*Applicable Regulation (Statute Authority)*	*General Description*	*Finalized Changes in FRM*
2-Cycle Testing	49 CFR 531.6(a) citing 40 CFR part 600 and 49 CFR 533.6 citing 40 CFR part 600 (49 U.S.C. 32904)	Vehicle testing is conducted by EPA using the Federal Test Procedure (Light-duty FTP or ''city'' test) and Highway Fuel Economy Test (HFET or ''highway'' test).	No changes.
AC efficiency FCIV	49 CFR 531.6(b)(1) and 49 CFR 533.6(c)(1) (49 U.S.C. 32904) citing 40 CFR 86.1868-12	This adjustment to the results from the 2-cycle testing accounts for fuel consumption improvement from technologies that improve AC efficiency that are not accounted for in the 2-cycle testing. The AC efficiency FCIV program began in MY 2017 for NHTSA.	Yes: Changes to 49 CFR 531.6 and 533.6 to align with EPA's regulations and eliminate AC efficiency FCIVs for BEVs starting in MY 2027.

Off-cycle FCIV	49 CFR 531.6(b)(2) and (3) and 49 CFR 533.6(c)(3) and (4) (49 U.S.C. 32904) citing 40 CFR 86.1869-12	This adjustment to the results from the 2-cycle testing accounts for fuel consumption improvement from technologies that are not accounted for or not fully accounted for in the 2-cycle testing. The off-cycle FCIV program began in MY 2017 for NHTSA.	Yes: Changes to 49 CFR 531.6 and 533.6 to align with EPA's regulations and eliminate off-cycle menu FCIVs for BEVs and to eliminate the 5-cycle and alternative approvals starting in MY 2027. PHEVs retain benefits for ICE operation only. Phasing out off-cycle FCIVs for OCs between MY 2027 and 2033. Adding a 60-day response deadline for requests for information regarding off-cycle requests for MY 2025-2026.
Advanced full-size pickup trucks FCIV	49 CFR 533.6(c)(2) citing 40 CFR 86.1870-12 (49 U.S.C. 32904)	This adjustment increases a manufacturer's average fuel economy for hybridized and other performance-based technologies for MY 2017 and 2024.	No changes. The program is set to sunset in MY 2024 and NHTSA is not extending it.
Dedicated alternative fueled vehicles	49 CFR 536.10 citing 40 CFR 600.510-12(c) (49 U.S.C. 32905(a) and (c))	EPA calculates the fuel economy of dedicated alternative fueled vehicles assuming that a gallon of liquid/gaseous alternative fuel is equivalent to 0.15 gallons of gasoline per 49 U.S.C. 32905(a). For BEVs, EPA uses the petroleum equivalency factor as defined by the Department of Energy (see 10 CFR 474.3) (per 49 U.S.C. 32904(a)(2).	No changes.
Dual-fueled vehicles	49 CFR 536.10 citing 40 CFR 600.510-12(c) (49 U.S.C. 32905(b), (d), and (e) and 49 U.S.C. 32906(a))	EPA calculates the fuel economy of dual-fueled vehicles using a utility factor to account the portion of power energy consumption from the different energy sources. Starting in MY 2019, there is no adjustment to the fuel economy of dual-fueled vehicles other than electric vehicles. For electric vehicles, EPA uses DOE's petroleum equivalency factor for the electric portion of the vehicle's expected energy use (per 49 U.S.C. 32904(a)(2).	No changes.
Earning and Using Credits for Overcompliance and Addressing Shortfalls			
Earning Credits	49 CFR 536.4 (49 U.S.C. 32903(a))	Manufacturers earn credits for each one tenth of mile by which the average fuel economy vehicles in a particular compliance category in a model year exceeds the applicable fuel economy standard, multiplied by the number of vehicles sold in that compliance category (i.e., fleet).	No changes.
Carry-forward Credits	49 U.S.C. 32903(a)(2)	Manufacturers may carry-forward credits up to 5 model years into the future	No changes.
Carry-back Credits	49 CFR part 536 (49 U.S.C. 32903(a)(1))	Manufacturers may carry-back credits up to 3 model years into the past	No changes.

Credit Transfers	49 CFR part 536 (49 U.S.C. 32903(g))	Manufacturers may transfer credits between their fleets to increase a fleet's average fuel economy by up to 2 mpg. Manufacturers may not use transferred credits to meet the minimum domestic passenger car standards (see 49 U.S.C. 32903(g)(4) and 49 CFR 536.9)	No changes.
Credit Trading	49 CFR 536.8 (49 U.S.C. 32903(f))	Manufacturers may trade an unlimited quantity of credits into fleets of the same compliance category. A manufacturer may then transfer those credits to a different compliance category, but only up to the 2mpg limit for transfers. Manufacturers may not use traded credits to meet the minimum domestic passenger car standards (see 49 U.S.C. 32903(f)(2) and 49 CFR 536.9).	No changes.
Civil Penalties	49 CFR 578.6(h) (49 U.S.C. 3912.)	Starting in 2023, the civil penalty for CAFE shortfalls is $16 for each tenth of a mpg that a manufacturer's average fuel economy falls short of the standard multiplied by the total number of vehicles in the affected fleet. The civil penalty is adjusted periodically for inflation.	No changes.

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a. Determining Compliance

This first component of NHTSA's enforcement program pertains to how NHTSA determines compliance with its fuel economy standards. In general, as prescribed by Congress, NHTSA finalizes footprint-based fleet average standards for LDVs for fuel economy on a mpg basis. In that way, the standard applies to the fleet as a whole and not to a specific vehicle, and manufacturers can balance the performance of their vehicles and technologies in complying with standards. Also, as specified by Congress, light-duty vehicles is separated into three fleets for compliance purposes: passenger automobiles manufactured domestically (referred to as domestic passenger vehicles), passenger automobiles not manufactured domestically (referred to as import passenger vehicles), and non-passenger automobiles (which are referred to as light trucks and includes MDPVs that meet certain criteria).[1504] Each manufacturer must comply with the fleet average standard derived from the model type target standards. These target standards are taken from a set of curves (mathematical functions) for each fleet. Vehicle testing for the light-duty vehicle program is conducted by EPA using the FTP (or ''city'' test) and HFET (or ''highway'' test).[1505]

At the end of each model year, EPA determines the fleet average fuel economy performance for the fleets as determined by procedures set forth in 40 CFR part 600. NHTSA then confirms whether a manufacturer's fleet average performance for each of its fleets of LDVs exceeds the applicable target-based fleet standard. NHTSA makes its ultimate determination of a manufacturer's CAFE compliance obligation based on official reported and verified CAFE data received from EPA. Pursuant to 49 U.S.C. 32904(e), EPA is responsible for calculating manufacturers' CAFE values so that NHTSA can determine compliance with its CAFE standards. The EPA-verified data is based on information from NHTSA's testing,[1506] its own vehicle testing, and FMY data submitted by manufacturers to EPA pursuant to 40 CFR 600.512–12. A manufacturer's FMY report must be submitted to EPA no later than 90 days after December 31st of the model year including any adjustment for off-cycle credits for the addition of technologies that result in real-world fuel improvements that are not accounted for in the 2-cycle testing as specified in 40 CFR part 600 and 40 CFR part 86. EPA verifies the data submitted by manufacturers and issues final CAFE reports that are sent to manufacturers and to NHTSA electronically between April and October of each year. NHTSA's database system identifies which fleets do not meet the applicable CAFE fleet standards and calculates each manufacturer's credit amounts (credits for vehicles exceeding the standards), credit excesses (credits accrued for a fleet exceeding the standards), and shortfalls (amount by which a fleet fails to meet the standards). A manufacturer meets NHTSA's fuel economy standard if its fleet average performance is greater than or equal to its required standard or its MDPCS (whichever is greater). Congress enacted MDPCSs per 49 U.S.C. 32902. These standards require that domestic passenger car fleets meet a minimum level directed by statute and then projected by the Secretary at the time a standard is promulgated in a rulemaking. In addition, manufacturers are not allowed to use traded or transferred credits to resolve credit shortfalls resulting from failing to exceed the MDPCS.

If a manufacturer's fleet fails to meet a fuel economy standard, NHTSA will provide written notification to the manufacturer that it has not met the standard. The manufacturer will be required to confirm the shortfall and must either submit a plan indicating how to allocate existing credits, or if it does not have sufficient credits available in that fleet, how it will address the shortfall either by earning, transferring and/or acquiring credits or by paying the appropriate civil penalty. The manufacturer must submit a plan or payment within 60 days of receiving agency notification. Credit allocation plans received from the manufacturer will be reviewed and approved by NHTSA. NHTSA will approve a credit allocation plan unless it finds the proposed credits are unavailable or that it is unlikely that the plan will result in the manufacturer earning sufficient credits to offset the shortfall. If a plan is approved, NHTSA will revise the manufacturer's credit account accordingly. If a plan is rejected, NHTSA will notify the manufacturer and request a revised plan or payment of the appropriate fine.

b. Flexibilities

As mentioned above, there are flexibilities manufacturers can use in the CAFE program for compliance purposes. Two general types of flexibilities that exist for the CAFE program include (1) FCIVs that can be used to increase CAFE values; and (2) credit flexibilities. To provide context for the changes NHTSA is making, a discussion of two types of FCIVs is provided below. These credits are for the addition of technologies that improve air/conditioning efficiency (AC FCIVs) and other ''off-cycle'' technologies that reduce fuel consumption that are not accounted for in the 2-cycle testing (OC FCIVs).[1507] NHTSA is not making any changes to the provisions regarding the flexibilities for how credits may be used. A discussion of these flexibilities can be found in previous rulemakings.[1508]

As mentioned above, the light-duty CAFE program provides FCIVs for improving the efficiency of AC systems.[1509] Improving the efficiency of these systems is important because AC usage places a load on the Internal Combustion Engines (ICE) that results in additional fuel consumption, and AC systems are virtually standard automotive accessories, with more than 95 percent of new cars and light trucks sold in the U.S. equipped with mobile AC systems. Together, this means that AC efficiency can have a signifant impact on total fuel consumption. The AC FCIV program is designed to incentivize the adoption of more efficient systems, thereby reducing energy consumption across the fleet.

Manufacturers can improve the efficiency of AC systems through redesigned and refined AC system components and controls. These improvements, however, are not measurable or recognized using 2-cycle test procedures because the AC is turned off during the CAFE compliance 2-cycle testing. Any AC system efficiency improvements that reduce load on the engine and improve fuel economy, therefore, cannot be accounted for in those tests.

In the joint final rule for model year 2017–2025, EPA extended its AC

[1504] 49 U.S.C. 32903(g)(6)(B).

[1505] 40 CFR part 600.

[1506] NHTSA conducts vehicle testing under its ''Footprint'' attribute conformity testing to verify track width and wheelbase measurements used by manufacturers to derive model type target standards. If NHTSA finds a discrepancy in its testing, manufacturers will need to make changes in their final reports to EPA.

[1507] Manufacturers may also earn FCIVs for full size pickup trucks which have hybrid or electric drivetrains or have advanced technologies as specified in 40 CFR 86.1870–12. NHTSA is not providing an overview of these credits because NHTSA is not making any changes for these credits. For an an explanation of these credits see the May 2, 2022 final rule (87 FR 25710, page 26025).

[1508] October 15, 2012 (77 FR 63125, starting at page 62649) and May 2, 2022 (87 FR 25710, starting at page 26025).

[1509] 40 CFR 1868–12.

efficiency program to allow manufacturers to generate fuel consumption improvement values for NHTSA's CAFE compliance.[1510] The program provides a technology menu that specifies improvement values for the addition of specific technologies and specifies testing requirements to confirm that the technologies provide emissions reductions when installed as a system on vehicles.[1511] A vehicle's total AC efficiency FCIV is calculated by summing the individual values for each efficiency-improving technology used on the vehicle, as specified in the AC menu or by the AC17 test result.[1512] The total AC efficiency FCIV sum for each vehicle is capped at 5.0 grams/mile for cars and 7.2 grams/mile for trucks.[1513] Related to AC efficiency improvements, the off-cycle program, discussed in the next section, contains fuel consumption improvement opportunities for technologies that help to maintain a comfortable air temparature of the vehicle interior without the use of the A/C system (*e.g.,* solar reflective surface coating, passive cabin ventilation). These technologies are listed on a thermal control menu that provides a predefined improvement value for each technology.[1514] If a vehicle has more than one thermal control technology, the improvement values are added together, but subject to a cap of 3.0 grams/mile for cars and 4.3 grams/mile for trucks.[1515] Manufacturers seeking FCIVs beyond the regulated caps may request the added benefit for AC technology under the off-cycle program alternative approval pathway.

In addition to allowing improvements for AC efficiency technologies, manufacturers may also generate FCIVs for off-cycle technologies. ''Off-cycle'' technologies are those that reduce vehicle fuel consumption in the real world, but for which the fuel consumption reduction benefits cannot be fully measured under the 2-cycle test procedures used to determine compliance with the fleet average standards. The FTP and HFET cycles are effective in measuring improvements in most fuel efficiency-improving technologies; however, they are unable to measure or do not adequately represent certain fuel economy-improving technologies because of limitations in the test cycles. For example, off-cycle technologies that improve emissions and fuel efficiency at idle (such as ''stop start'' systems) and those technologies that improve fuel economy to the greatest extent at highway speeds (such as active grille shutters that improve aerodynamics) are not fully accounted for in the 2-cycle tests.

In the model year 2017–2025 CAFE rulemaking, EPA, in coordination with NHTSA, established regulations extending benefits for off-cycle technologies and created FCIVs for the CAFE program starting with model year 2017.[1516] Under its EPCA authority for CAFE, EPA determined that the summation of the all the FCIVs values (for AC, OC, and advanced technology incentives for full size pickup trucks) in grams per mile could be converted to equivalent gallons per mile totals for improving CAFE values. More specifically, EPA normalizes the FCIVs values based on the manufacturer's total fleet production and then applies the values in an equation that can increase the manufacturer's CAFE values for each fleet instead of treating them as separate credits as they are in the GHG program.[1517]

For determining FCIV benefits, EPA created three compliance pathways for the off-cycle program: (1) menu technologies, (2) 2 to 5-Cycle Testing, and (3) an alternative approval methodology. Manufacturers may generate off-cycle credits or improvements through the approved menu pathway without agency approval. Manufacturers report the inclusion of pre-defined technologies for vehicle configurations that utilize the technologies, from the pre-determined values listed in 40 CFR 86.1869–12(b), in their PMY and MMY reports to NHTSA and then in their final reports to EPA.

For off-cycle technologies both on and off the pre-defined technology list, EPA allows manufacturers to use 5-cycle testing to demonstrate off-cycle improvements.[1518] Starting in model year 2008, EPA developed the ''five-cycle'' test methodology to measure fuel economy for the purpose of improving new car window stickers (labels) and giving consumers better information about the fuel economy they could expect under real-world driving conditions. The ''five-cycle'' methodology was also able to capture real-world fuel consumption improvements that weren't fully reflected on the ''two-cycle'' test and EPA established this methodology as a pathway for a manufacturer to obtain FCIVs. The additional testing allows emission benefits to be demonstrated over some elements of real-world driving not captured by the two-cycle testing, including high speeds, rapid accelerations, hot temperatures, and cold temperatures. Under this pathway, manufacturers submit test data to EPA, and EPA determines whether there is sufficient technical basis to approve the value of the off-cycle credit or fuel consumption improvement.

The final pathway allows manufacturers to earn OC FCIVs is an alternative pathway that requires a manufacturer to seek EPA review and approval.[1519] This path allows a manufacturer to submit an application to EPA to request approval of off-cycle benefits using an alternative methodology. The application must describe the off-cycle technology and how it functions to reduce CO_2 emissions under conditions not represented in the 2-cycle testing, as well as provide a complete description of the methodology used to estimate the off-cycle benefit of the technology and all supporting data, including vehicle testing and in-use activity data. A manufacturer may request that EPA, in coordination with NHTSA, informally review their methodology prior to undertaking testing and/or data gathering efforts in support of their application. Once a manufacturer submits an application, EPA publishes a notice of availability in the **Federal Register** notifying the public of a manufacturer's proposed alternative off-cycle benefit calculation methodology.[1520] EPA makes a decision whether to approve the methodology after consulting with NHTSA and considering the public comments.

c. Civil Penalties

If a manufacturer does not comply with a CAFE standard and cannot or chooses not to cover the shortfall with credits, EPCA provides for the assessment of civil penalties. The Act specifies a precise formula for determining the amount of civil penalties for such noncompliance. Starting in model year 2024, the penalty, as adjusted for inflation by law,

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[1510] October 15, 2012 final rule (77 FR 62624).

[1511] *See* 40 CFR 86.1868–12(e) through (g).

[1512] *See* 40 CFR 1868–12(g)(2)(iii).

[1513] *See* 40 CFR 1868–12(b)(2).

[1514] *See* 40 CFR 86.1869–12(b)(1)(viii)(A) through (E).

[1515] *See* 40 CFR 86.1869–12(b)(1)(viii).

[1516] Off-cycle credits were extened to light-duty vehicles under the CAFE program in the October 15, 2012 final rule (77 FR 62624).

[1517] FCIV_{AC} and FCIV_{OC} are each deducted as separately calculated credit values from the fleet fuel economy per 40 CFR 600.510–12(c)(1)(ii) and 40 CFR 600.510–12(c)(3)(i) through (ii). AC efficiency credit falls under FCIV_{AC}, while thermal load improvement technology credit falls under FCIV_{OC}.

[1518] *See* 40 CFR 86.1869–12(c).

[1519] 40 CFR 86.1869–12(d).

[1520] EPA may waive the notice and comment requirements for technologies for which EPA has previously approved a methodology for determining credits. See 40 CFR 86.1869–12(d)(2)(ii).

is $17 for each tenth of a mpg that a manufacturer's average fuel economy falls short of the standard multiplied by the total volume of those vehicles in the affected fleet (*i.e.,* import passenger vehicles, domestic passenger vehicles, or light trucks), manufactured for that model year.[1521] On November 2, 2015, the Federal Civil Penalties Inflation Adjustment Act Improvements Act (Inflation Adjustment Act or 2015 Act), Public Law 114–74, Section 701, was signed into law. The 2015 Act required Federal agencies to promulgate an interim final rule to make an initial ''catch-up'' adjustment to the civil monetary penalties they administer, and then to make subsequent annual adjustments. The amount of the penalty may not be reduced except under the unusual or extreme circumstances specified in the statute,[1522] which have never been exercised by NHTSA in the history of the CAFE program.

NHTSA may also assess general civil penalties as prescribed by Congress under 49 U.S.C. 32912(a). A person that violates section 32911(a) of title 49 is liable to the United States Government for a civil penalty of not more than $51,139 for each violation.[1523] A separate violation occurs for each day the violation continues. These penalties apply in cases in which NHTSA finds a violation outside of not meeting CAFE standards, such as those that may occur due to violating information requests or reporting requirements as specified by Congress or codified in NHTSA's regulations.

2. Heavy-Duty Pickup Trucks and Vans

As with the CAFE enforcement program, there are three primary components to NHTSA's compliance program for heavy-duty vehicles: (1) determining compliance; (2) using flexibilities and incentives; and (3) paying civil penalties for shortfalls. The following table provides an overview of the Heavy-Duty Fuel Efficiency Program for HDPUVs.

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[1521] *See* 49 U.S.C. 32912(b) and 49 CFR 578.6(h)(2). For MYs before 2019, the penalty is $5.50; for MYs 2019 through 2021, the civil penalty is $14; for MY 2022, the civil penalty is $15; for MY 2023, the civil penalty is $16.

[1522] *See* 49 U.S.C. 32913.

[1523] The maximum civil penalty under § 32912 is periodically adjusted for inflation.

Credit Transfers	49 CFR part 536 (49 U.S.C. 32903(g))	Manufacturers may transfer credits between their fleets to increase a fleet's average fuel economy by up to 2 mpg. Manufacturers may not use transferred credits to meet the minimum domestic passenger car standards (see 49 U.S.C. 32903(g)(4) and 49 CFR 536.9)	No changes.
Credit Trading	49 CFR 536.8 (49 U.S.C. 32903(f))	Manufacturers may trade an unlimited quantity of credits into fleets of the same compliance category. A manufacturer may then transfer those credits to a different compliance category, but only up to the 2mpg limit for transfers. Manufacturers may not use traded credits to meet the minimum domestic passenger car standards (see 49 U.S.C. 32903(f)(2) and 49 CFR 536.9).	No changes.
Civil Penalties	49 CFR 578.6(h) (49 U.S.C. 3912.)	Starting in 2023, the civil penalty for CAFE shortfalls is $16 for each tenth of a mpg that a manufacturer's average fuel economy falls short of the standard multiplied by the total number of vehicles in the affected fleet. The civil penalty is adjusted periodically for inflation.	No changes.

Table VII-2: Overview of Compliance for Heavy-Duty Pickups and Vans (HDPUV) Fuel Efficiency Program

Fleet Performance Requirements			
Component	***Applicable Regulation (Statutory Authority)***	***General Description***	***Finalized Changes in FRM***
Fuel Efficiency Standards	49 CFR 535.5 (49 U.S.C. 32902(k))	Standards are attribute-based fleet average standards expressed in gallons per 100 miles. The standards are based on the capability of each model to perform work. A model's work-factor is a measure of its towing and payload capacities and whether equipped with a 4-wheel drive configuration. In setting standards for the Heavy-Duty National Program, NHTSA seeks to implement standards designed to achieve the maximum feasible improvement in fuel efficiency, adopting and implementing test procedures, measurement metrics, fuel economy standards, and compliance and enforcement protocols that are appropriate, cost effective, and technologically feasible.	Yes: Amendments to 49 CFR 535.5(a) to set standards for MY2030 and beyond for HDPUVs (with increases in the standards between MY 2030 and 2035).
Determining Average Fleet Performance and Certification Flexibilities			
Component	***Applicable Regulation (Statute Authority)***	***General Description***	***Finalized Changes in FRM***
2-Cycle Testing	49 CFR 535.6(a) citing 40 CFR 86.1819-14	Vehicle testing is conducted by EPA using the Federal Test Procedure and Highway Fuel Economy Test (HFET or ''highway'' test).	No changes.
Exclusion of Vehicles Not Certified as Complete Vehicles	49 CFR 535.5(a)(5)	The standards for heavy duty pickup trucks do not apply to vehicles that are chassis-certified with respect to EPA's criteria pollutant test procedure in 40 CFR part 86, subpart S. Instead, the vehicles must comply with the vehicle standards in 49 CFR 535.5(b) and the engines used in these vehicles must comply with 49 CFR 535.5(d).	No changes.
Sister Vehicles	49 CFR 535.5(a)(6)	Manufacturers may certify cab-complete vehicles based on a complete sister vehicle for purposes of the fuel consumption standards in 49 CFR 535.5. Manufacturers may also ask to apply the sister vehicle provision to Class 2b and Class 3 incomplete vehicles in unusual circumstances.	No changes.
Loose Engines	49 CFR 535.5(a)(7)	For MY 2023 and earlier, manufacturers may certify spark-ignition engines with identical hardware compared with engines used in complete pickup trucks as having a fuel consumption target value and test result equal to that of the complete vehicle in the applicable test group with the highest equivalent test weight except that a manufacturer may not generate fuel consumption credits.	No changes. The loose engine program ends after MY 2023.

Optional Certification for Heavier Vehicles	49 CFR 535.5(a)(6)(i)	Manufacturers may certify any complete or cab-complete spark-ignition vehicles above 14,000 pounds GVWR and at or below 26,000 pounds GVWR to the fuel consumption standards for heavy duty pickup trucks and vans in 49 CFR 535.5(a).	No changes.
Alternative Fuel Conversions	49 CFR 535.5(a)(8) citing 40 CFR 85.525	Alternative fuel vehicle conversions may demonstrate compliance with the standards of this part or other alternative compliance approaches allowed by EPA in 40 CFR 85.525.	No changes.
Earning and Using Credits for Overcompliance and Addressing Shortfalls			
Earning Credits	49 CFR 535.7(a)	Manufacturers earn fuel consumption credits (FCCs) for the weighted value representing the extent to which a vehicle or engine family or fleet within a particular averaging set performs better than the standard.	No changes.
Advanced technology credits	49 CFR 535.7(a)(1)(iii); 49 CFR 535.7(f)(1) citing 40 CFR 86.1819-14 and 86.1865	Manufacturer may generate credits for vehicle or engine families or subconfigurations containing vehicles with advanced technologies (i.e., hybrids with regenerative braking, vehicles equipped with Rankine-cycle engines, electric and fuel cell vehicles).	No changes.
Advanced technology credit multiplier	49 CFR 535.5(a)(9) and 535.7(f)(1)	In the 2016 Phase 2 Final Rule, EPA and NHTSA explained that manufacturers may increase advanced technology credits by a 3.5 multiplier for plug-in hybrid electric vehicles, 4.5 for all-electric vehicles, and 5.5 for fuel cell vehicles through My 2027.	No changes. The proposed changes in the NPRM to make technical amendments to accurately reflect changes contemplated by 2016 final rule establishing requirements for Phase 2 were made in the final rule NHTSA published on March 15, 2024 (89 FR 18808), which made minor technical amendments to the heavy-duty fuel efficiency program. The multiplier for advanced technology credits ends after MY 2027.
Innovative and off-cycle technology credits	49 CFR 535.7(a)(1)(iv); 49 CFR 535.7(f)(2) citing 49 CFR 86.1819-14(d)(13), 1036.610 and 1037.610	Manufacturer may generate credits for vehicle or engine families or subconfigurations having fuel consumption reductions resulting from technologies not reflected in the GEM simulation tool or in the FTP chassis dynamometer.	Yes: Changes to eliminate innovative and off-cycle technology credits for heavy-duty pickup trucks and vans in MY 2030 and beyond.
Banked Surplus Credits	49 CFR 535.7 (a)(3)(i)	Manufacturers may carry-forward credits up to 5 model years into the future	No changes.
Credit Deficit	49 CFR 535.7(a)(5)	Manufacturers may carry-back credits up to 3 model years into the past.	No changes.

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a. Determining Compliance

In general, NHTSA finalizes attribute-based fleet average standards for fuel consumption of HDPUVs on a gal/100-mile basis using a similar compliance strategy as required for light-vehicles in the CAFE program. For these vehicles, the agencies set standards based on attribute factors relative to the capability of each model to perform work, which the agencies defined as ''work factor.'' More specifically, the work-factor of each model is a measure of its towing and payload capacities and whether equipped with a 4-wheel drive configuration. Each manufacturer must comply with the fleet average standard derived from the unique subconfiguration target standards (or groups of subconfigurations approved by EPA in accordance with 40 CFR 86.1819–14(a)(4)) of the model types that make up the manufacturer's fleet in a given model year. Each subconfiguration has a unique attribute-based target standard, defined by each group of vehicles having the same work factor. These target standards are taken from a set of curves (mathematical functions), with separate performance curves for gasoline and diesel vehicles.[1524] In general, in calculating HDPUVs, fleets with a mixture of vehicles with increased payloads or greater towing capacity (or utilizing four-wheel drive configurations) will face numerically less stringent standards than fleets consisting of less powerful vehicles. Vehicle testing for both the HDPUV and LDV programs is conducted on chassis dynamometers using the drive cycles from FTP and HFET.[1525] While the FTP and the HFET driving patterns are identical to that of the light-duty test cycles, other test parameters for running them, such as test vehicle loaded weight, are specific to complete HDPUV vehicles.

Due to the variations in designs and construction processes, optional requirements were added to simplify testing and compliance burdens for cab-chassis Class 2b and 3 vehicles. Requirements were added to treat cab-chassis Class 2b and 3 vehicles (vehicles sold as incomplete vehicles with the cab substantially in place but without the primary load-carrying enclosure) as equivalent to the complete van or truck product from which they are derived. Manufacturers determine which complete vehicle configurations most closely matches the cab-chassis product leaving its facility and include each of these cab-chassis vehicles in the fleet averaging calculations, as though it were identical to the corresponding complete ''sister'' vehicle. The Phase 1 MDHD program also added a flexibility known as the ''loose engine'' provision. Under the provision, spark-ignition (SI) engines produced by manufacturers of HDPUVs and sold to chassis manufacturers and intended for use in vocational vehicles need not meet the separate SI engine standard, and instead may be averaged with the manufacturer's HDPUVs fleet.[1526] This provision was adopted primarily to address small volume sales of engines used in complete vehicles that are also sold to other manufacturers.

And finally, at the end of each model year NHTSA confirms whether a manufacturer's fleet average performance for its fleet of HDPUVs exceeds the applicable target-based fleet standard using the model type work factors. Compliance with the fleet average standards is determined using 2-cycle test procedures. However, manufacturers may also earn credits for the addition of technologies that result in real-world fuel improvements that are not accounted for in the 2-cycle testing. If the fleet average performance exceeds the standard, the manufacturer complies for the model year. If the manufacturer's fleet does not meet the standard, the manufacturer may address the shortfall by using a credit flexibility equal to the credit shortage in the averaging set. The averaging set balance is equal to the balance of earned credits in the account plus any credits that are traded into or out of the averaging set during the model year. If a manufacturer cannot meet the standard using credit flexibilities, NHTSA may assess a civil penalty for any violation of this part under 49 CFR 535.9(b).

b. Flexibilities

Broadly speaking, there are two types of flexibilities available to manufacturers for HDPUVs. Manufacturers may improve fleet averages by (1) earning fuel consumption incentive benefits and by (2) transferring or trading in credits that were earned through overcompliance with the standards. First, as mentioned above, manufacturers may earn credits associated with fuel efficiencies that are not accounted for in the 2-cycle testing.[1527] Second, manufacturers may transfer credits into like fleets (*i.e.,* averaging sets) from other manufacturers through trades.[1528]

Unlike the light-duty program, there is no AC credit program for HDPUVs. Currently, these vehicles may only earn fuel consumption improvement credits through an off-cycle program, which may include earning credits for AC efficiency improvements. In order to receive these credits, manufacturers must submit a request to EPA and NHTSA with data supporting that the technology will result in measurable, demonstrable, and verifiable real-world CO_2 emission reductions and fuel savings. After providing an opportunity for the public to comment on the manufacturer's methodology, the agencies make a decision whether to approve the methodology and credits.[1529]

In addition to earning additional OC FCIVs, manufacturers have the flexibility to transfer credits into their fleet to meet the standards. Manufacturers may transfer in credits from past (carry-forward credits) model years of the same averaging set.[1530] Manufacturers may also trade in credits earned by another manufacturer, as long as the credits are traded into the same averaging set/fleet type. Manufacturers may not transfer credits between light-duty CAFE fleets and heavy-duty fleets. Likewise, a manufacturer cannot trade in credits from another manufacturer's light-duty fleet to cover shortfalls in their heavy-duty fleets. NHTSA oversees these credit transfer and trades through regulations issued in 49 CFR 535.7, which includes reporting requirements for credit trades and transfers for medium- and heavy-duty vehicles.

c. Civil Penalties

The framework established by Congress and codified by NHTSA for civil penalties for the heavy-duty program is quite different from the light-duty program.

[1524] However, both gasoline and diesel vehicles in this category are included in a single averaging set for generating and using credit flexibilities.

[1525] The light-duty FTP is a vehicle driving cycle that was originally developed for certifying light-duty vehicles and subsequently applied to heavy-duty chassis testing for criteria pollutants. This contrasts with the Heavy-duty FTP, which refers to the transient engine test cycles used for certifying heavy-duty engines (with separate cycles specified for diesel and spark-ignition engines).

[1526] *See* 40 CFR 86.1819–14(k)(8).

[1527] Off-cycle benefits were extened to heavy-duty pickup trucks and vans through the—MDHD—Phase 1 program in the September 15, 2011 final rule (76 FR 57106).

[1528] *See* 49 CFR 535.7(a)(2)(iii) and 49 CFR 535.7(a)(4).

[1529] *See* 49 CFR 535.7(f)(2), 40 CFR 86.1819–14(d)(13), and 40 CFR 86.1869–12(c) through (e).

[1530] *See* 49 CFR 535.7(a)(3)(i), 49 CFR 535.7(a)(3)(iv), 49 CFR 535.7(a)(2)(v), and 49 CFR 535.7(a)(5).

Congress did not prescribe a specific rate for the fine amount for civil penalties but instead gave NHTSA general authority under EISA, as codified at 49 U.S.C. 32902(k), to establish requirements based upon appropriate measurement metrics, test procedures, standards, and compliance and enforcement protocols for HD vehicles. NHTSA interpreted its authority and developed an enforcement program to include the authority to determine and assess civil penalties for noncompliance that would impose penalties based on the following criteria, as codified in 49 CFR 535.9(b).

In cases of noncompliance, NHTSA assesses civil penalties based upon consideration of the following factors:

- Gravity of the violation.
- Size of the violator's business.
- Violator's history of compliance with applicable fuel consumption standards.
- Actual fuel consumption performance related to the applicable standard.
- Estimated cost to comply with the regulation and applicable standard.
- Quantity of vehicles or engines not complying.
- Civil penalties paid under CAA section 205 (42 U.S.C. 7524) for noncompliance for the same vehicles or engines.

NHTSA considers these factors in determining civil penalties to help ensure, given NHTSA's wide discretion, that penalties would be fair and appropriate, and not duplicative of penalties that could be imposed by EPA. NHTSA goal is to avoid imposing duplicative civil penalties, and both agencies consider civil penalties imposed by the other in the case of non-compliance with GHG and fuel consumption regulations. NHTSA also uses the ''estimated cost to comply with the regulation and applicable standard,''[1531] to ensure that any penalties for non-compliance will not be less than the cost of compliance. It would be contrary to the purpose of the regulation for the penalty scheme to incentivize noncompliance. Further, NHTSA set its maximum civil penalty amount not to exceed the limit that EPA is authorized to impose under the CAA. The agencies agreed that violations under either program should not create greater punitive damage for one program over the other. Therefore, NHTSA's maximum civil penalty for a manufacturer would be calculated as the: Aggregate Maximum Civil Penalty for a Non-Compliant Regulatory Category = (CAA Limit) × (production volume within the regulatory category). This approach applies for all HD vehicles including pickup trucks and vans as well as engines regulated under NHTSA's fuel consumption programs.

C. Changes Made by This Final Rule

The following sections describe the changes NHTSA is finalizing in order to update its enforcement programs for light-duty vehicles and for HDPUVs. These changes include: (1) amending NHTSA's regulations to reflect the elimination of AC and OC FCIVs for BEVs in model year 2027 and beyond; (2) adding a provision that references that a utility factor will be used for the calculation of FCIVs for PHEVs; (3) amending NHTSA's regulations to reflect the phasing out of OC FCIVs for all vehicles in the CAFE program by model year 2033 (10 g/mi for model year 2027–2030, 8 g/mi for model year 2031, 6 g/mi for model year 2032, and 0 g/mi for model year 2033 and beyond); (4) amending NHTSA's regulations to reflect the elimination of 5-cycle and alternative approval pathways for OC FCIVs in CAFE in model year 2027 and beyond; (5) adding language to NHTSA's regulations stating that NHTSA will recommend denial of requests for OC FCIVs under the alternative if requests for information are not responded to within set amounts of time for model years 2025–2026 for the CAFE program; (6) eliminating OC technology credits for HDPUVs in model year 2030 and beyond; and (7) making an assortment of minor technical amendments. These changes reflect experience gained in the past few years and are intended to improve the programs overall.

NHTSA received comments from a variety of stakeholders related to compliance and enforcement. The commenters included manufacturers and trade groups, environmental groups, and groups involved in the supply of fuels and vehicle manufacturing resources. NHTSA received comments on all of our proposed changes as well as comments about other compliance issues that commenters believed should be addressed. NHTSA also received comments of general support or opposition to the changes proposed for the AC/OC program.[1532] [1533] The comments are discussed in more detail below.

1. Elimination of OC and AC Efficiency FCIVs for BEVs in the CAFE Program

In the NPRM, NHTSA proposed removing AC and OC FCIVs for BEVs, which manufacturers can use to improve their fuel economy values to comply with CAFE standards. NHTSA proposed this change to align with EPA's May 5, 2023 proposal and because the FCIVs were based on information about energy savings for ICE vehicles and, therefore, are not representative of energy savings for BEVs.[1534] The CAFE program currently allows manufacturers to increase their fleet average fuel economy performance with FCIVs for vehicles equipped with technologies that improve the efficiency of the vehicles' AC systems and otherwise reduce fuel consumption. The FCIVs were intended to incentize the adoption of fuel economy-improving technologies whose benefits are not accounted for in the 2-cycle testing required by 49 U.S.C. 32904(c) to be used for calculating fuel economy performance for CAFE compliance. NHTSA also sought comment on whether, instead of eliminating FCIVs for BEVs completely, new off-cycle and AC values for BEVs based on BEV powertrains rather than IC engines should be proposed, and, if so, how those proposed values should be calculated.

On April 18, 2024, EPA issued a final rule that eliminated, beginning in model year 2027, eligibility to gain FCIVs for any vehicles that do not have IC engines.[1535] Thus, BEVs are no longer eligible for these FCIVs after model year 2026. NHTSA believes that eliminating AC and OC FCIVs was appropriate because BEVs are currently generating FCIVs in a program designed to account for fuel economy improvements that were based on reductions in emissions and fuel consumption of ICE vehicles. In the OC program specifically, we note that the values associated with menu technologies were based on ICE vehicles with exhaust emissions and fuel consumption. While there may be AC and other technologies that improve BEV energy consumption, the values associated with AC FCIVs and the OC menu FCIVs were based on ICE vehicles and, therefore, are not representative of energy consumption reductions in BEVs. When EPA and NHTSA adopted these flexibilities in the 2012 rule, there was little concern about this issue

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[1531] *See* 49 CFR 535.9(b)(4).

[1532] Ceres BICEP, Docket No. NHTSA–2023–0022–61125, at 1; Joint NGOs, Docket No. NHTSA–2023–0022–61944, at 61.

[1533] DENSO, Docket No. NHTSA–2023–0022–60676–A1, at 3; Ford, Docket No. NHTSA–2023–0022–60837, at 10; Nissan, Docket No. NHTSA–2023–0022–60696, at 9; Stellantis, Docket No. NHTSA–2023–0022–61107, at 3; Volkswagen, Docket No. NHTSA–2023–0022–58702, at 4; Mitsubishi, Docket No. NHTSA–2023–0022–61637, at 9.

[1534] 88 FR 29184.

[1535] 89 FR 27842. See especially 40 CFR 86.1869–12 and 600.510–12(c)(3)(ii).).

because BEV sales were only a small fraction of total sales.[1536] [1537] Now, however, BEVs are gaining FCIVs as part of the fleet compliance that aren't representative of real-world energy consumption reduction. Therefore, NHTSA proposed changes to align its regulation with EPA's proposal to end off-cycle and AC efficiency FCIVs for light-duty vehicles with no IC engine beginning in model year 2027.

NHTSA received comments both supportive and in opposition of the proposal regarding the elimination of FCIVs for BEVs. While NHTSA appreciates these comments, NHTSA first notes that NHTSA's final rule changes on this matter are technical in nature. That is, while NHTSA's regulations reference a manufacturer's ability to generate FCIVs for CAFE compliance purposes, the authority for determining how to calculate fuel economy performance rests with EPA.[1538] NHTSA's regulations merely reference EPA's provisions that stipulate how manufacturers may generate FCIVs. Therefore, the comments requesting NHTSA to make changes regarding FCIVs are, as a general matter, outside the scope of this rulemaking.

Although NHTSA's regulatory changes to reflect the elimination of FCIVs for BEVs are technical in nature, NHTSA believes that it is still appropriate to summarize and discuss comments received and explain how NHTSA's views on this issue align with EPA's regulatory changes. NHTSA received several comments from vehicle manufacturers and trade groups expressing opposition of the proposal to eliminate AC and OC FCIVs for BEVs. Some of the comments expressed general opposition to the proposal, while others requested that the elimination of FCIVs for BEVs be delayed until model year 2032.[1539] Ford suggested that FCIVs for BEVs be phased out over time, as they "believe that the program can serve an important function during this transitional period towards electrification." [1540] Other commenters noted the current incentives drive research and adoption of AC and OC efficiencies on all vehicles and that without the incentives the research may not be financially practical for OEMs.[1541] DENSO also commented that if research and development of AC and OC efficiencies is not incentivized on all vehicles there may be less penetration of AC and OC technologies on ICE vehicles as manufacturers focus research and development on EVs.[1542]

Commenters also noted that the technologies do still have a benefit in BEVs, particularly for AC efficiencies.[1543] Lucid noted that "AC efficiency improvements have a direct impact on tailpipe emissions for ICE vehicles" [1544] and that, as a corollary, "improvements to AC efficiency in EVs yield benefits such as better vehicle range, increased vehicle efficiency, and less demand on the grid." [1545] Lucid states that these benefits "directly impact EV usage, vehicle miles traveled, and consumer sentiment toward the adoption of EVs." [1546] BMW believes NHTSA should maintain the current OC and AC efficiency FCIVs for BEVs.[1547] Volkswagenexpressed concern that the elimination of OC and AC efficiency FCIVs for BEVs would put BEVs and PHEVs at a disadvantage.[1548]

Several commenters had suggestions for how to improve the accuracy of AC and off-cycle values for BEVs. DENSO proposed several options for improving the calculation of AC and OC FCIVs.[1549] Rivian noted that BEVs can still benefit from improved AC systems in the form of less energy usage, and that as such, NHTSA should allow BEVs to earn AC credits.[1550] ICCT, in contrast, commented that "while BEVs also benefit from improved AC system efficiency and off-cycle technologies, BEVs do not require the additional incentive provided by AC and OC credits." ICCT recommended that NHTSA not introduce new OC and AC credits for BEVs and further recommended that "if NHTSA decides to introduce such credits, they should be based on relative or percentage-based reductions in 5-cycle energy consumption." [1551]

NHTSA also received several comments expressing support of the proposal to eliminate AC and OC efficiency FCIVs for BEVs, including Arconic, the Joint NGOs, ICCT, and ACEEE.[1552]

In light of EPA's April 18, 2024 final rule, NHTSA is finalizing its proposed regulatory changes that note that starting in 2027, manufacturers may not generate FCIVs for vehicles that lack an internal combustion engine. As mentioned earlier, the original AC and OC FCIVs were exclusively developed with IC engines efficiency assumptions and are not representative of energy consumption reductions for BEVs. They correspond to motor vehicle emissions reductions that occur when the AC systems on ICE vehicles are operated more efficiently, which in turn reduces their use of electricity produced by the alternator and engine, and which in turn reduces fuel consumption of the motor vehicle engine. The AC FCIV program provides an incentive for manufacturers to increase the efficiency of their AC systems and in turn reduce the fuel consumption by the vehicle engine. Also, OC FCIVs were intended to incentivize the adoption of technologies that would not have been adopted if the program didn't exist.

NHTSA has also recently observed that BEVs that have received AC and OC FCIVs have increased their fuel economy compliance values by significant amounts due to the required use of the petroleum equivalence factor to determine the fuel economy of BEVs combined with the order of operation for calculating FCIVs per EPA's regulation.[1553] [1554] As a result, a manufacturer that is solely building electric vehicles may generate unrealistic FCIVs. For example, assuming the performance of a 2022 Tesla Model 3 Long Range AWD variant based on the 2-cycle test, NHTSA would calculate the same vehicle in model year 2031 to have a fuel economy of 154.3 MPGe based on the 2-cycle test and

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[1536] *See* 77 FR 62624, (October 15, 2012).

[1537] 2022 EPA Automotive Trends Report at Table 4.1 on page 74.

[1538] 49 U.S.C. 32904.

[1539] The Alliance, Docket No. NHTSA–2023–0022–60652–A2, at 11; HATCI, Docket No. NHTSA–2023–0022–48991, at 1; Kia, Docket No, NHTSA–2023–0022–58542–A1, at 6; MEMA, Docket No. NHTSA–2023–0022–59204–A1, at 7.

[1540] Ford, Docket No. NHTSA–2023–0022–60837, at 9.

[1541] HATCI, Docket No. NHTSA–2023–0022–48991–A1, at 3; Kia, Docket No. NHTSA–2023–0022–58542–A1, at 3, 6 and 7; MEMA, Docket No. NHTSA–2023–0022–59204–A1, at 7; Toyota, Docket No. NHTSA–2023–0022–61131, at 2.

[1542] DENSO, Docket No. NHTSA–2023–0022–60676–A1, at 4.

[1543] HATCI, Docket No. NHTSA–2023–0022–48991–A1, at 3; Kia, Docket No. NHTSA–2023–0022–58542–A1, at 7; MEMA, Docket No. NHTSA–2023–0022–59204–A1, at 7; Toyota, Docket No. NHTSA–2023–0022–61131, at 2 and 25.

[1544] Lucid, Docket No. NHTSA–2023–0022–50594, at 6.

[1545] Lucid, Docket No. NHTSA–2023–0022–50594, at 6.

[1546] Lucid, Docket No. NHTSA–2023–0022–50594, at 6.

[1547] BMW, Docket No. NHTSA–2023–0022–58614, at 3

[1548] Volkswagen, Docket No. NHTSA–2023–0022–58702, at 4.

[1549] DENSO, Docket No. NHTSA–2023–0022–60676–A1, at 5.

[1550] Rivian, Docket No. NHTSA–2023–0022–59765, at 9.

[1551] ICCT, Docket No. NHTSA–2023–0022–54064, at 24.

[1552] Arconic, Docket No. NHTSA–2023–0022–60684, at 4; ACEEE, Docket No. NHTSA–2023–0022–48374, at 2; Joint NGOs, Docket No. NHTSA–2023–0022–61944–A2, at 62; ICCT, Docket No. NHTSA–2023–0022–54064, at 24.

[1553] 40 CFR 600.116–12.

[1554] 40 CFR 600.510–12(c).

DOE's revised PEF.[1555] Assuming that the model year 2031 vehicle received the same amount of FCIVs as the model year 2022 vehicle (5 grams/mile AC FCIVs and 5 grams/mile OC FCIVs, for a total of 10 grams/mile), the FCIVs would increase the vehicle's CAFE fuel economy to 186.7 MPGe. This is a difference of 32.4 MPGe. In comparison, if an ICE vehicle with a fuel economy of 35 MPG based on the 2-cycle test generated the same amount of AC and OC FCIVs (10 grams/mile), the FCIVs would only increase the vehicle's fuel economy to 36.4 MPG. This is just an increase of 1.4 mpg from an increase of 10 grams/mile of AC and OC. Not only is the increase in MPGe for the BEV in this example a 21% increase as compared to a 4% increase in the MPG for the ICE vehicle, but it is also unrealistic to believe that an increase of 32.4 MPGe is representative of the energy consumption savings provided by BEVs having the technology for which they generated the FCIVs. To provide perspective, the fuel savings for an ICE vehicle that increased its fuel economy by 32.4 MPG would be enormous if applied across a fleet of vehicles. While AC and OC technologies may increase the energy efficiency of BEVs, the current FCIVs generated by these vehicles are out of proportion to the real-world benefit they provide.

2. Addition of a Utility Factor for Calculating FCIVs for PHEVs

Additionally, in light of its proposal to eliminate FCIVs for BEVs, NHTSA sought comment on adjusting FCIVs for PHEVs based on a utility factor for the portion of usage where the vehicle is operated by the IC engine to align with EPA's May 5, 2023 NPRM. For CAFE compliance purposes, the fuel economy of dual-fueled vehicles, such as PHEVs, is calculated by EPA using a utility factor to account the portion of power energy consumption from the different energy sources.[1556] A utility factor of 0.3, for example, means that the vehicle is estimated to operate as an IC Engine vehicle 70 percent of the vehicle's VMT. NHTSA requested comment on aligning NHTSA's regulations to align with EPA's proposal to reduce FCIVs for PHEVs proportional to the estimated percentage of VMT that the vehicles would be operated as EVs.

We received only one comment on the proposal to adjust FCIVs for PHEVs using a utility factor calculation. The Joint NGOs commented that NHTSA should eliminate FCIVs for PHEVs when they are operating on electricity.[1557]

On April 18, 2024, EPA issued a final rule that added a utility factor to the calculation of FCIVs for PHEVs.[1558] Accordingly, starting in model year 2027, the calculated credit value for PHEVs will be scaled based on the vehicle's estimated utility factor.[1559] In light of the changes made in EPA's final rule, NHTSA is finalizing technical amendments to note that FCIVs for PHEVs will be based on a utility factor starting in model year 2027. While PHEVs will remain eligible for off-cycle FCIVs under the CAFE program, EPA finalized, as a reasonable approach for addressing off-cycle FCIVs for PHEVs, to scale the calculated FCIVs for PHEVs based on the vehicle's assigned utility factor. For example, if a PHEV has a utility factor of 0.3, meaning the vehicle is estimated to operate as an ICE vehicle 70 percent of the vehicle's VMT, the PHEV will earn an off-cycle FCIV that is 70 percent of the FCIV value of a fully ICE vehicle to properly account for the value of the off-cycle FCIVs corresponding to expected engine operation. This calculation methodology is consistent with EPA's decision to eliminate FCIVs for BEVs because the values are not representative of real-world improvements in energy consumption during electric operation. As has been the case for FCIVs under the existing regulations, individual vehicles may generate more FCIVs than the fleetwide cap value but the fleet average credits per vehicle must remain at or below the applicable menu cap.

3. Phasing Out OC FCIVs by MY 2033

NHTSA also requested comment on phasing out OC FCIVs for all vehicles before MY 2031. As a possible approach, NHTSA sought comment on phasing out the off-cycle menu cap by reducing it to 10 g/mi in model year 2027, 8 g/mi in model year 2028, 6 g/mi in model year 2029, and 3 g/mi in model year 2030 before eliminating OC FCIVs in model year 2031. As noted above, FCIVs were added to the CAFE program by the October 15, 2012 final rule and manufacturers were able to start earning OC FCIVs starting in model year 2017.[1560]

The value of FCIVs for OC technologies listed on the predefined list are derived from estimated emissions reductions associated with the technologies which is then converted into an equivalent improvement in MPG. These values, however, were established based on model year 2008 vehicles and technologies assessed during the 2012 rulemaking and may now be less representative of the fuel savings provided by the off-cycle technologies as fuel economy has improved over time. While NHTSA's CAFE standards have increased over time, FCIVs for some menu technologies have remained the same, which may result in the FCIVs being less representative of MPG improvements provided by the off-cycle technologies. As fuel economy improves, FCIVs increasingly represent a larger portion of their fuel economy and there is not currently a mechanism to confirm that the off-cycle technologies provide fuel savings commensurate with the FCIVs the menu provides. Further, issues such as the synergistic effects and overlap among off-cycle technologies take on more importance as the FCIVs represent a larger portion of the vehicle fuel economy. Therefore, NHTSA requested comment on phasing out FCIVs for off-cycle technologies for ICE vehicles. Alternatively, NHTSA requested comment on whether new values should be established for off-cycle technologies that are more representative of the real-world fuel savings provided by these technologies, and if so, how the appropriate values for these technologies could be calculated.

On April 18, 2024, EPA issued a final rule that phases out OC FCIVs between model years 2031–2033.[1561] While EPA proposed phasing out OC FCIVs in model years 2027–2033,[1562] EPA finalized provisions to retain the current 10 g/mile menu cap through model year 2030, with a phase-out of 8/6/0 g/mile in model years 2031–2033. As discussed above, while NHTSA's regulations reference a manufacturer's ability to generate FCIVs for CAFE compliance purposes, the authority for determining how to calculate fuel economy performance rests with EPA.[1563] Therefore, EPA's final rule has already effectuated the phase-out of FCIVs for OC technology. As such, NHTSA is moving forward with finalizing amendments to update NHTSA's regulations to align with EPA's phase-out of FCIVs for OC technologies.

Although NHTSA's regulatory changes to reflect the phase out of OC FCIVs are technical in nature, NHTSA believes that it is still appropriate to summarize and discuss comments

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[1555] 89 FR 22041 (March 29, 2024).

[1556] 40 CFR 600.116–12.

[1557] Joint NGOs, Docket No. NHTSA–2023–0022–61944–A2, at 62.

[1558] 89 FR 27842, 27922.

[1559] 89 FR 27842, 27922.

[1560] 77 FR 62624.

[1561] 89 FR 27842.

[1562] 88 FR 29184 (May 5, 2023).

[1563] 49 U.S.C. 32904.

received and explain how NHTSA's views on this issue align with EPA's regulatory changes.

Several commenters wrote in support of phasing out OC FCIVs. ICCT[1564] commented in support of phasing out the OC FCIVs by model year 2031. ACEEE commented that ''[t]here is also limited evidence of the benefits of the credits in reducing real-world emissions so without any reforms NHTSA should similarly phase out the program.''[1565] ACEEE also commented that the additional incentives currently provided by NHTSA weaken the standards. Lucid,[1566] Rivian,[1567] and Tesla submitted comments encouraging NHTSA to remove OC FCIVs in model year 2027 along with the elimination of OC and AC efficiency FCIVs for BEVs.[1568] Rivian also commented that if NHTSA does not eliminate OC FCIVs in model year 2027 they should phase out OC FCIVs before the proposed model year 2031 timeframe, reducing the menu cap to zero by model year 2030 since NHTSA does not currently have a mechanism to confirm that the off-cycle technologies provide fuel savings commensurate with the menu values.[1569] Toyota also commented in support of NHTSA's proposal to phase out menu credits.[1570]

Other commenters requested to extend the phase out through model year 2032 and coordinate with EPA on the phase-out.[1571] Porsche suggested that NHTSA extend the menu phase-out by allowing manufacturers to continue to apply for credits for menu items after the phase out of OC FCIVs.[1572] Subaru commented requesting that ''already approved efficiency technologies are allowed to maintain their value for as long as they are applied to future vehicles.[1573] Large investments were made into these technologies, which should be recognized for their real-world energy savings.''

Commenters argued for maintaining menu OC FCIVs for several reasons including: (1) the incentives will help manufacturers as they transition to EVs, (2) the incentives support the development and application of technology which improves fuel economy, (3) OC technology provides real world benefits to fuel economy. Commenters noted that the incentives from the OC program help manufacturers to meet NHTSA's standards and will help manufacturers navigate the transition to EVs.[1574] Other commenters noted that these incentives reflect real-world fuel economy improvements.[1575] While these technologies do provide some real-world fuel economy improvements, it is difficult to quantify how much real world benefit they provide. Commenters[1576] noted that without the incentives manufacturers will be less likely to develop new OC technology that could assist in NHTSA's overall goal of reducing fuel consumption. Additionally, manufacturers would be less likely to include OC technologies in their fleets without the incentives.[1577]

Kia commented that they oppose NHTSA's proposal to phase out and eventually eliminate off-cycle technology menu FCIVs by MY2031 and instead urged NHTSA to retain existing off-cycle menu-based credits through at least 2032.[1578] Kia noted that the increased off-cycle menu cap (from 10 g/mi to 15 g/mi) for model years 2023–2026 signaled to industry that EPA, and therefore NHTSA, would continue to encourage and account for these off-cycle technologies.[1579] Kia further stated that it had made significant investments in these technologies and would appreciate the opportunity to earn a return on investment.[1580]

As discussed above, NHTSA is finalizing minor regulatory changes to align with EPA's phase-out of menu credits over the model year 2030–2033 timeframe. NHTSA believes the slower phase-out schedule provided in EPA's regulation will provide additional time for manufacturers who have made substantial use of off-cycle credits in their product planning to pursue alternative pathways for improving fuel economy. The extended phase-out schedule also will address lead time in the early years of the program. Instead of the proposed menu cap phase-out of 10/8/6/3/0 g/mile in model years 2027–2031, EPA finalized provisions that retain the 10 g/mile menu cap through model year 2030, with a phase-out of 8 g/mi in model year 2031, 6 g/mi in model year 2032 and 0 g/mi in model year 2033. We believe this phase-out schedule is an appropriate way to address concerns that the off-cycle credits may not be reflective of the real-world emissions impact of the off-cycle technologies.

4. Elimination of the 5-Cycle and Alternative Approval Pathways for CAFE

In the NPRM, NHTSA proposed eliminating both the 5-cycle pathway and the alternative pathway for off-cycle FCIVs for light-duty vehicles starting in model year 2027. NHTSA proposed this change to align with EPA and believes it to be appropriate because we do not believe that the benefit to manufacturers is significant enough to justify the significant amount of time and resources required to be committed to reviewing and approving requests. Further, based on the general degree of robustness of data provided by manufacturers to EPA and NHTSA for approval consideration, the analysis is often delayed and may ultimately result in a denial, causing undesirable and often unnecessary delays to final compliance processing.

In the NPRM, NHTSA stated that it does not believe that the 5-cycle pathway is beneficial to manufacturers or to NHTSA, as the pathway is used infrequently, provides minimal benefits, and requires a significant amount of time for review. Historically, only a few technologies have been approved for FCIVs through 5-cycle testing. The 5-cycle demonstrations are less frequent than the alternative pathway due to the complexity and cost of demonstrating real-world emissions reductions for technologies not listed on the menu. NHTSA's proposal aligned with EPA's proposed rule issued on May 5, 2023.[1581]

NHTSA also proposed eliminating the alternative approval process for off-

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[1564] ICCT, Docket No. NHTSA–2023–0022–54064, at 24.

[1565] ACEEE, Docket No. NHTSA–2023–0022–60684, at 4.

[1566] Lucid, Docket No. NHTSA–2023–0022–50594, at 7.

[1567] Rivian, Docket No. NHTSA–2023–0022–28017, at 1.

[1568] Tesla, Docket No. NHTSA–2023–0022–60093, at 16.

[1569] Rivian, Docket No. NHTSA–2023–0022–59765, at 8.

[1570] Toyota, Docket No. NHTSA–2023–0022–61131, at 26.

[1571] The Alliance, Docket No. NHTSA–2023–0022–60652–A2, at 11; DENSO, Docket No. NHTSA–2023–0022–60676–A1, at 3.

[1572] Porsche, Docket No. NHTSA–2023–0022–59240, at 9.

[1573] Subaru, Docket No. NHTSA–2023–0022–58655, at 4.

[1574] The Alliance, Docket No. NHTSA–2023–0022–60652–A3, at 34; Ford, Docket No. NHTSA–2023–0022–60837, at 9; MEMA, Docket No. NHTSA–2023–0022–59204–A1, at 7; NADA, NHTSA–2023–0022–58200, at 13.

[1575] MEMA, Docket No. NHTSA–2023–0022–59204–A1, at 3; Subaru, Docket No. NHTSA 2023–002–58655, at 4; Stellantis, Docket No. NHTS–2023–0022–61107, at 10; BMW, Docket No. NHTSA–2023–0022–58614, at 4.

[1576] DENSO, Docket No. NHTSA–2023–0022–60676–A1, at 3; Ford, Docket No. NHTSA–2023–0022–60837, at 9; Kia, Docket No. NHTSA–2023–0022–58542–A1, at 3.

[1577] Kia, Docket No. NHTSA–2023–002–58542–A1, at 6–7.

[1578] Kia, Docket No. NHTSA–2023–002–58542–A1, at 6–7.

[1579] Kia, Docket No. NHTSA–2023–002–58542–A1, at 6–7.

[1580] Kia, Docket No. NHTSA–2023–002–58542–A1, at 6–7.

[1581] 88 FR 29184.

cycle FCIVs starting in model year 2027. This proposal also aligned with EPA's May 5, 2023 NPRM.[1582] Manufacturers currently seek EPA review, in consultation with NHTSA, through a notice and comment process, to use an alternative methodology other than the menu or 5-cycle methodology.[1583] Manufacturers must provide supporting data on a case-by-case basis demonstrating the benefits of the off-cycle technology on their vehicle models. Manufacturers may also use the alternative approval pathway to apply for FCIVs for menu technologies where the manufacturer is able to demonstrate FCIVs greater than those provided by the menu.

NHTSA proposed eliminating the alternative approval process for off-cycle credits starting in model year 2027 to align with EPA's proposal. The alternative approval process has been used successfully by several manufacturers for high efficiency alternators, resulting in EPA adding them to the off-cycle menu beginning in model year 2021.[1584] The program has resulted in a number of concepts for potential off-cycle technologies over the years, but few have been implemented, at least partly due to the difficulty in demonstrating the quantifiable real-world fuel consumption reductions associated with using the technology. Many FCIVs sought by manufacturers have been relatively small (less than 1 g/mile). Manufacturers have commented several times that the process takes too long, but the length of time is often associated with the need for additional data and information or issues regarding whether a technology is eligible for FCIVs. NHTSA has been significantly impacted in conducting its final compliance processes due to the untimeliness of OC approvals. For these reasons, NHTSA proposed edits to update NHTSA's regulations to align with EPA's proposal to eliminate the alternative approval process for earning off-cycle fuel economy improvements starting in model year 2027.

On April 18, 2024, EPA issued a final rule that eliminated the 5-cycle and alternative pathways, starting in model year 2027 for earning off-cycle fuel economy improvements.[1585] Under EPA's final rule, manufacturers may no longer generate credits under the 5-cycle and alternative pathways starting in model year 2027.[1586] Therefore, NHTSA is moving forward with the proposed amendments to its regulations to align with the changes in EPA's regulations.

While NHTSA received comments both supporting and opposing NHTSA's proposed regulatory changes, NHTSA's regulatory changes are technical in nature. That is, the elimination of FCIVs for BEVs starting in model year 2027 was effectuated as part of EPA's April 18, 2024 rule.[1587] While NHTSA's regulations reference a manufacturer's ability to generate FCIVs in the CAFE program, the authority for determining how to calculate fuel economy performance rests with EPA.[1588] NHTSA's regulations merely reference EPA's provisions that stipulate how manufacturers may generate FCIVs. Therefore, the comments requesting NHTSA to make changes regarding FCIVs are, as a general matter, outside the scope of this rulemaking.

Although NHTSA's regulatory changes to reflect the elimination of 5-cycle and alternative approval pathways are technical in nature, NHTSA believes that it is still appropriate to respond to comments and explain how NHTSA's views on this issue align with EPA's. NHTSA received comments both supporting and opposing the proposals to eliminate the 5-cycle and alternative approval pathways.[1589] [1590]

Hyundai America Technical Center, Inc. (HATCI), Kia, Mitsubishi and MECA expressed concerns with the removal of the 5-cycle and alternative approval pathways. MECA commented acknowledging the complexity of the 5-cycle and alternative approval processes and the fact that not many manufacturers have used these pathways. MECA also stated that they believe that there might be increased adoption of the 5-cycle and alternative approval pathways with other incentives being sunset and, for this reason, requested that NHTSA keep these pathways available for OEMs.[1591] HATCI requested that NHTSA extend the 5-cycle and alternative pathways through at least 2032, believing that if these pathways are eliminated manufacturers will abandon these technologies.[1592] Kia commented that the alternative and 5-cycle approaches would be helpful to manufacturers during the transition to EVs.[1593] Mitsubishi also requested that NHTSA extend the 5-cycle and alternative approval method past model year 2032.[1594] In response to these comments, NHTSA notes that the requested changes are outside of the scope of this rulemaking. With EPA's April 18, 2024 final rule, manufacturers may not generate FCIVs through either the 5-cycle or alternative approval pathways beginning in model year 2027. NHTSA further notes that due to the limited use of these pathways to date, NHTSA does not believe this change will have a substantial negative impact on manufacturers.

Some commenters requested that technologies approved via the alternative approval or 5-cycle pathway prior to model year 2027 that are not included on the menu credit still be eligible for the credit amount for which they were approved.[1595] NHTSA understands these commenters to be asking that manufacturers be permitted to generate FCIVs that were approved through the alternative approval and 5-cycle pathways as long as FCIVs are permitted to be generated for technologies on the menu even though new technologies would not be able to be approved. NHTSA notes, however, that EPA's final rule precludes manufacturers from generating FCIVs through the alternative approval and 5-cycle pathways starting in model year 2027 and does not merely prevent new technologies to be approved.

Commenters also requested that NHTSA add to the off-cycle credits menu list all of the previously approved 5-cycle and public process pathway credits with an associated increase in the cap.[1596] HATCI also requested that, after adding the previously approved technologies to the menu, the menu cap be adjusted accordingly.[1597] In response to these comments, NHTSA notes that the menu for FCIVs is found within EPA's regulations and that the authority for determining how fuel economy performance is calculated rests with EPA.[1598] NHTSA has not identified authority that would allow it to establish new technologies to a menu

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[1582] 88 FR 29184.

[1583] 40 CFR 86.1869–12(d).

[1584] 85 FR 25236 (April 30, 2020).

[1585] 89 FR 27842.

[1586] See changes to 40 CFR 86.1869–12 (89 FR 27842, 28199).

[1587] 89 FR 27842.

[1588] 49 U.S.C. 32904.

[1589] Arconic, Docket No. NHTSA–2023–0022–48374–A1, at 2.

[1590] DENSO, Docket No. NHTSA–2023–0022–60676–A1, at 4.

[1591] MECA, Docket No. NHTSA–2023–0022–63053- A1, at 7.

[1592] HATCI, Docket No. NHTSA–2023–0022–48991, at 3.

[1593] Kia, Docket No. NHTSA–2023–0022–58542–A1, at 7.

[1594] Mitsubishi, Docket No. NHTSA–2023–0022–61637, at 8.

[1595] BMW, Docket No. NHTSA–2023–0022–58614, at 4; DENSO, Docket No. NHTSA–2023–0022–60676–A1, at 4.

[1596] HATCI, Docket No. NHTSA–2023–002–48991, at 3; BMW, Docket No. NHTSA–2023–0022–58614, at 4; DENSO, Docket No. NHTSA–2023–002–60676–A1, at 4.

[1597] HATCI, Docket No. NHTSA–2023–002–48991, at 3.

[1598] 49 U.S.C. 32904.

for FCIVs. NHTSA further notes that the few credits that have been approved under the 5-cycle and alternative approval pathways have been specific to individual vehicle models and there is not sufficient data on the real-world emissions impact of these technologies across a wide range of vehicle segments to determine an appropriate menu credit for these technologies.

For the foregoing reasons, NHTSA is finalizing its proposed amendments to align with EPA's April 18, 2024 final rule, which eliminated the generation of FCIVs through the 5-cycle and alternative approvals process starting in model year 2027.

5. Requirement To Respond To Requests for Information Regarding Off-Cycle Requests Within 60 Days for LDVs for MYs 2025 and 2026

For model year 2025 and model year 2026, NHTSA proposed creating a time limit to respond to requests for information regarding OC petitions for light-duty vehicles. This limit was proposed to allow for the timelier processing of OC petitions. In the last rule, NHTSA added provisions clarifying and outlining the deadlines for manufacturers to submit off-cycle requests.[1599] Since laying out those new requirements, NHTSA has identified another point in the OC request process that is delaying the timely processing of the requests. When considering OC petitions, NHTSA and EPA frequently need to request additional information from the manufacturer, and NHTSA observes that it has sometimes taken OEMs an extended amount of time to respond to these requests.

NHTSA proposed to create a deadline of 60 days for responding to requests for additional information regarding OC petitions. If the manufacturer does not respond within the 60-day limit with the requested information, NHTSA may recommend that EPA deny the petition for the petitioned model year. NHTSA may grant an extension for responding if the manufacturer responds within 60 days with a reasonable timeframe for when the requested information can be provided to the agencies. If an OEM does not respond to NHTSA's call for additional data regarding the request within a timely manner, the request may be denied. If the request is denied, it will no longer be considered for the model year in question. If the denied petition is for model year 2025 the OEM may still request consideration of the credits for the following year. A manufacturer may request consideration for later model years by responding to NHTSA/EPA's data request and expressing such interest.

NHTSA received one comment in support of the proposal, from the Joint NGOs,[1600] and one comment opposing the proposal, from Toyota.[1601] Toyota stated that NHTSA "should not add additional requirements to the FCIV application process as these alternative methods wind down over the 2025–2026 model years." [1602] Toyota stated that approval of applications has taken years in some cases with the loss of planned FCIVs due to no fault of the manufacturer.[1603] Toyota also stated that an application for an off-cycle technology is often followed by several rounds of additional data requests from NHTSA and EPA with long delays between each submission of data by the manufacturer and requested that if NHTSA were to enact a deadline on manufacturers, they establish a commensurate deadline for agency action on the requested data submissions."[1604]

After considering the comments, NHTSA has decided to move forward with adopting the 60-day deadline for responding in an attempt to streamline the process for manufacturers as well as NHTSA. While NHTSA understands manufacturers frustration with the extended time period the application review can take, the FCIV approval process involves significant agency review to confirm that technologies for which the manufacturer is requesting FCIVs provides real world benefits and that the FCIV value is appropriate. Since the manufacturers are petitioning for the FCIVs, NHTSA does not believe it is appropriate for the manufacturer to delay the process by not responding to agency requests for information in a timely manner. Accordingly, NHTSA is finalizing a change to the regulation to notify manufacturers that NHTSA may recommend denial of their OC FCIV petition if the manufacturer does not respond within 60-days. This change applies for model year 2025–26.

6. Elimination of OC Technology Credits for Heavy-Duty Pickup Trucks and Vans Starting in Model Year 2030

In the NPRM, NHTSA proposed eliminating OC technology credits for HDPUVs for the same reasons discussed above for eliminating the 5-cycle and alternative pathways for OC technology credits in the CAFE program starting in model year 2030. Currently, manufacturers of HDPUVs may only earn credits through an off-cycle program that involves requesting public comment and case-by-case review and approval. Since its inception, the program has involved lengthy and resource-intensive processes that have not resulted in significant benefits to the HDPUV fleet. At this time, NHTSA does not believe the benefit provided by these credits justifies NHTSA's time and resources. Accordingly, NHTSA proposed to end the off-cycle program for HDPUVs starting in model year 2030. NHTSA also requested comment on eliminating OC technology credits for BEVs if NHTSA did not eliminate OC technology credits for all HDPUVs. In the current regulation, we consider all BEVs and PHEVs to have no fuel usage and we assume zero fuel consumption for compliance. Accordingly, these vehicles would go to negative compliance values if we allowed OC technology credits for BEVs.

NHTSA received only one comment specific to the proposal to remove OC FCIVs for HDPUVs. In the comment, Arconic[1605] expressed support of eliminating OC FCIVs for HDPUVs.

After considering the comments received, NHTSA has decided to move forward with the elimination of OC technology credits for heavy-duty pickup trucks and vans starting in model year 2030. As stated above, NHTSA believes the lengthy and resource-intensive processes involved with approving OC credits for HDPUVs has not resulted in significant benefits to the HDPUV fleet. Additionally, NHTSA believes that, even apart from process considerations, it is appropriate to eliminate OC FCIVs for HDPUV BEVs and PHEVs because they are considered to have no fuel usage and zero g/mile for compliance and allowing FCIVs to apply to these vehicles would result in negative compliance values.

7. Technical Amendments for Advanced Technology Credits

In addition to the changes discussed above, NHTSA is also making several minor technical amendments to 49 CFR parts 523, 531, 533, 535, 536 and 537. These amendments include technical amendments related to advanced technology credits in the Heavy-Duty National program as well as an assortment of technical amendments to update statutory citations and cross-references and to update language regarding medium-duty passenger

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[1599] See 49 CFR 531.6(b)(3)(i) and 49 CFR 533.6(c)(4)(i).

[1600] Joint NGOs, Docket No. NHTSA–2023–0022–61944–A2, at 66.

[1601] Toyota, Docket No. NHTSA–2023–0022–61131, at 26.

[1602] *Id.*

[1603] *Id.*

[1604] *Id.*

[1605] Arconic, Docket No. NHTSA–2023–0022–48374, at 2.

vehicles. Although some of these technical amendments were not included in the NPRM, NHTSA finds that notice and comment would be unnecessary. Pursuant to the Administrative Procedure Act (APA), a Federal agency must generally provide the public and notice and an opportunity to comment on agency rulemakings.[1606] The APA, however, creates an exception in cases where an agency for good cause determines ‘‘that notice and public procedure thereon are impractical, unnecessary, or contrary the public interest.’’ [1607] Because all of the changes discussed below involve only minor, technical amendments to NHTSA's regulations, the agency has determined that notice and comment are unnecessary. NHTSA will briefly discuss each of these technical amendments below.

In the NPRM, NHTSA proposed to make technical amendments to the current regulations pertaining to advanced technology credits. In the Phase 2 rule for the Heavy-Duty National Program, NHTSA and EPA jointly explained that we were adopting advanced technology credit multipliers for three types of advanced technologies. As described in the 2016 final rule, there would be a 3.5 multiplier for advanced technology credits for plug-in hybrid vehicles, a 4.5 multiplier for advanced technology credits for all-electric vehicles, and a 5.5 multiplier for advanced technology credits for fuel cell vehicles. The agencies stated that their intention in adopting these multipliers was to create a meaningful incentive to manufacturers considering adopting these technologies in their vehicles. The agencies further noted that the adoption rates for these advanced technologies in heavy vehicles was essentially non-existent at the time the final rule was issued and seemed unlikely to grow significantly within the next decade without additional incentives. Because of their large size, the agencies decided to adopt them as an interim program that would continue through model year 2027. These changes, however, were not accurately reflected in the regulatory changes made by the final rule. Since issuing the NPRM, NHTSA published a final rule which made technical amendments to the regulations for the heavy-duty fuel efficiency program and finalized the proposed change.[1608] The current text of 49 CFR 535.7 now states that for Phase 2, advanced technology credits may be increased by the corresponding multiplier through model year 2027.

Additionally, the final rule also explained that because of the adoption of the large multipliers, the agencies were discontinuing the allowance to use advanced technology credits across averaging sets.[1609] This change was also not accurately reflected in the regulatory changes. NHTSA proposed making a technical amendment to reflect the intended change.

NHTSA received several comments about this technical amendment. Rivian Automotive, LLC (Rivian) suggests that NHTSA should accelerate the phase out of advanced technology multipliers ‘‘in recognition of a much-changed industry and vehicle technology landscape.’’ [1610] The Auto Innovators,[1611] GM,[1612] MECA,[1613] and Stellantis commented supporting NHTSA's clarification that the advanced technology multipliers will extend through model year 2027, with Stellantis adding that this ‘‘avoids disrupting OEM product plans by changing a previously published final rule.’’ [1614] The Strong PHEV Coalition commented that NHTSA ‘‘should provide a small credit multiplier in model year 2027 to 2030 for several advanced technologies including PHEVs with a long all-electric range that are not being produced today because they need extra lead time to develop.’’ [1615]

In response to the comments received, NHTSA notes that substantive changes to the advanced technology multiplier are out of scope of this rulemaking. Accordingly, NHTSA is not phasing out the advanced technology multipliers sooner than model year 2027, as Rivian requested, nor is NHTSA extending the multipliers through model year 2030, as the Strong PHEV Coalition requested. NHTSA is instead making the technical amendments that were proposed in the NPRM, which clarifies that advanced technology multipliers may be used through model year 2027, but they may not be used across averaging sets.

While NHTSA added clarifying language to 49 CFR 535.7 in the final rule published on March 15, 2024, which made technical amendments to the regulations for heavy-duty fuel efficiency program, NHTSA is making additional corrections, as proposed in the NPRM, to clarify that only advanced technology credits earned in Phase 1 may be used across averaging sets. Specifically, NHTSA is amending 49 CFR 535.7 (a)(2)(iii) to clarify that positive credits, other than advanced technology credits earned in Phase 1, generated and calculated within an averaging set may only be used to offset negative credits within the same averaging set. NHTSA is adding the same type of clarification to § 535.7(a)(4)(i) by clarifying that other than advanced technology credits earned in phase 1, traded FCCs may be used only within the averaging set in which they were generated and clarifying that § 535.7(a)(4)(ii) only applies to advanced technology credits earned in Phase 1.

8. Technical Amendments to Part 523

NHTSA is making technical amendments to part 523 to provide clarity regarding medium-duty passenger vehicles. Although these amendments were not included in the NPRM, NHTSA has since identified a need to update NHTSA's regulation regarding medium-duty passenger vehicles by making minor changes. Specifically, these amendments are made to provide consistency throughout the regulation and to align with the statutory definition of medium-duty passenger vehicle.

a. 49 CFR 523.2 Definitions

NHTSA is updating the definitions of definitions of *base tire (for passenger automobiles, light trucks, and medium duty passenger vehicles), basic vehicle frontal area,* and *emergency vehicle* to change reference to ‘‘medium duty passenger vehicles’’ to ‘‘medium-duty passenger vehicles’’ for consistency with the term used in NHTSA's authorizing statute.

NHTSA is also updating the definitions of *full-size pickup truck* and *light truck* to change reference to ‘‘medium duty passenger vehicles’’ to ‘‘medium-duty passenger vehicles’’ for consistency. Additionally, NHTSA is updating both terms to clarify that the terms include medium-duty passenger vehicles that meet the criteria for those vehicles.

NHTSA is also replacing the term the term *medium duty passenger vehicle* with the term *medium-duty passenger vehicle* for consistency and is updating the definition to align with the statutory definition. The term *medium-duty passenger vehicle* is defined at 49 U.S.C. 32901(a)(19) as being defined in 40 CFR 86.1803–01 as in effect on the date of the enactment of the Ten-in-Ten Fuel Economy Act (Pub. L. 110–140, enacted

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[1606] 5 U.S.C. 553(b).

[1607] 5 U.S.C. 553(b)(4)(B).

[1608] March 15, 2024 (89 FR 18808).

[1609] ‘‘Averaging set'' is defined at 49 CFR 535.4.

[1610] Rivian, NHTSA–2023–0022–59765, at 14.

[1611] The Alliance, Docket No. NHTSA–2023–0022–60652–A2, at 12.

[1612] GM, Docket No. NHTSA–2023–0022–60686–A1, at 7.

[1613] MECA, Docket No. NHTSA–2023–0022–63053- A1, at 7.

[1614] Stellantis, NHTSA–2023–0022–61107, at 11.

[1615] Strong PHEV Coalition, NHTSA–2023–0022–60193, at 5.

on December 19, 2007). Since the existing definition is not in complete alignment with the statutory definition, NHTSA is updating the regulatory definition. This change also provides greater clarity to manufacturers in regard to applicability of fuel economy standards to these vehicles.

b. 49 CFR 523.3 Automobile

NHTSA is amending § 523.3 to remove outdated language currently found in paragraph (b) that may cause confusion as to which vehicles are included as automobiles for purposes of CAFE standards. The text found in paragraph (b) was superseded by statutory changes in the Ten-in-Ten Fuel Economy Act (Pub. L. 110–140). With these statutory changes, all vehicles with a GVWR of 10,000 lbs. or less are subject to the CAFE standards with the exception of work trucks. A work truck is defined at 49 U.S.C. (a)(19) as a vehicle that is rated at between 8,500 and 10,000 lbs. gross vehicle weight and is not a medium-duty passenger vehicle. With this statutory change, all medium-duty passenger vehicles became subject to NHTSA's authority for setting CAFE standards. Medium-duty passenger vehicles are classified as either passenger cars or light trucks depending on whether the vehicle meets the requirements for light trucks found at § 523.5.

c. 49 CFR 523.4 Passenger Automobile

NHTSA is amending § 523.4 to add a sentence to clarify that a medium-duty passenger vehicle that does not meet the criteria for non-passenger motor vehicles in § 523.5 is a passenger automobile. As discussed above, since issuing the NPRM, NHTSA identified a need to provide greater clarity to the applicability of the CAFE standards to medium-duty passenger vehicles. NHTSA believes this technical amendment helps to provide that needed clarity.

d. 49 CFR 523.5 Non-Passenger Automobile

NHTSA is amending § 523.5 to add a sentence to clarify that a medium-duty passenger vehicle that meets the criteria for non-passenger motor vehicles in § 523.5 is a non-passenger automobile. This change, like the change to § 523.4, is intended to greater clarity regarding the applicability of the CAFE standards to medium-duty passenger vehicles.

e. 49 CFR 523.6 Heavy-Duty Vehicle

NHTSA is amending § 523.6 to correct a typo involving a missing hyphen after the word ''medium'' and to remove ''Heavy-duty trailers'' from the list of four regulatory categories. NHTSA is removing heavy-duty trailers from the list consistent with a November 2021 decision by the United States Court of Appeals for the District of Columbia Circuit.[1616] The D.C. Circuit decision vacated all portions of NHTSA and EPA's joint 2016 rule that apply to trailers.[1617] The underlying statute authorizes NHTSA to examine the fuel efficiency of and prescribe fuel economy standards for ''commercial medium-duty [and/or] heavy-duty on-highway vehicles.'' 49 U.S.C. 32902(b)(1)(C); 49 U.S.C. 32902(k)(2). The Court reasoned that trailers do not qualify as ''vehicles'' when that term is used in the fuel economy context because trailers are motorless and use no fuel.[1618] Accordingly, the Court held that NHTSA does not have the authority to regulate the fuel economy of trailers.[1619] Consistent with this decision, NHTSA is removing reference to heavy-duty trailers in § 523.6.

f. 49 CFR 523.8 Heavy-Duty Vocational Vehicle

NHTSA is making a minor amendment to § 523.8(b) to replace the term ''Medium duty passenger vehicles'' with ''Medium-duty passenger vehicles''. This minor technical amendment is being made for consistency.

9. Technical Amendments to Part 531

NHTSA is making several technical amendments to update references in the existing regulation and to include a definition for a term used in the regulation.

a. 49 CFR 531.1 Scope

NHTSA is amending § 531.1 to change the reference to section 502(a) and (c) of the Motor Vehicle Information and Cost Savings Act, to the appropriate codified provisions at 49 U.S.C. 32902. This change is intended to allow the reader to more easily identify the statutory definitions referenced in this section.

b. 49 CFR 531.4 Definitions

NHTSA is amending § 531.4 to change references to section 502 of the Motor Vehicle Information and Cost Savings Act, as amended by Public Law 94–163, to the appropriate codified provisions at 49 U.S.C. 32901. This change is to allow the reader to more easily identify the statutory definitions referenced in this section. NHTSA is also adding the term *domestically manufactured passenger automobile* and defining it as a vehicle that is deemed to be manufactured domestically under 49 U.S.C. 32904(b)(3) and 40 CFR 600.511–08. This second change is to provide greater clarity regarding a term that is used in the existing part 531.

c. 49 CFR 531.5 Fuel Economy Standards

NHTSA is making technical amendments to § 531.5(a) to correct a cross reference to NHTSA's alternative fuel economy standards for manufacturers who have petitioned and received exemptions from fuel economy standards under part 525. The correct cross-reference should be to paragraph (e). NHTSA is also making a technical amendment to § 531.5(b), (c), and (d) to add language clarifying that requirements in those paragraphs do not apply to manufacturers subject to alternative fuel economy standards in paragraph (e). These technical amendments clarify that manufacturers that have petitioned for and received exemptions from average fuel economy standards under 49 CFR part 525 are only subject to the alternative fuel economy standards set forth at § 531.5(e).

10. Technical Amendments to Part 533

NHTSA is making a few minor technical amendments to part 533 to update references to statutory authority.

a. 49 CFR 533.1 Scope

NHTSA is amending § 533.1 to change the reference to section 502(a) and (c) of the Motor Vehicle Information and Cost Savings Act, to the appropriate codified provisions at 49 U.S.C. 32902. This change is intended to allow the reader to more easily identify the statutory definitions referenced in this section.

b. 49 CFR 533.4 Definitions

NHTSA is amending § 533.4 to change references to section 501 of the Motor Vehicle Information and Cost Savings Act, as amended by Public Law 94–163, to the appropriate codified provisions at 49 U.S.C. 32901. This change is to allow the reader to more easily identify the statutory definitions referenced in this section. NHTSA is also removing the

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[1616] *Truck Trailer Mfrs. Ass'n, Inc.* v. *EPA,* 17 F.4th 1198, 1200 (D.C. Cir. 2021).

[1617] 81 FR 73478

[1618] *Truck Trailer Mfrs. Ass'n, Inc.,* 17 F.4th at 1200, at 1204–08.

[1619] *Id.* at 1208. For similar reasons, the Court also held that the statute authorizing EPA to regulate the emissions of ''motor vehicles'' does not encompass trailers. *Id.* at 1200–03. The Court affirmed, however, that both agencies still ''can regulate tractors based on the trailers they pull.'' *Id.* at 1208. Moreover, NHTSA is still authorized to regulate trailers in other contexts, such as under 49 U.S.C. chapter 301. See 49 U.S.C. 30102(a)(7) (defining ''motor vehicle'' to include ''a vehicle . . . drawn by mechanical power''); Truck Trailer Mfrs. Ass'n, Inc., 17 F.4th at 1207 (''A trailer is 'drawn by mechanical power.' '').

term domestically manufactured from § 533.4 because it not used within part 533. As discussed above, NHTSA is defining the term in § 531.4 because the term is used in part 531. NHTSA is also updating the term captive import to include reference to where the term is defined in section 502(b)(2)(E) of the Motor Vehicle Information and Cost Savings Act. This change is to allow the reader to more readily find the statutory definition of the term.

11. Technical Amendments to Part 535

NHTSA is making a few minor technical amendments to part 535 to update references to statutory authority and to update a cross reference to an EPA provision.

a. 49 CFR 535.4 Definitions

NHTSA is amending § 535.4 to change a reference to section 501 of the Motor Vehicle Information and Cost Savings Act, as amended by Public Law 94–163, to the appropriate codified definitions at 49 U.S.C. 32901. NHTSA is making this change to indicate that the terms *manufacture* and *manufacturer* are also codified at 49 U.S.C. 32901. NHTSA is also amending the introductory text of § 535.4 to remove the term ''commercial medium-duty and heavy-duty on highway vehicle'' because the term is not used in part 535, nor are the terms ''commercial medium-duty on highway vehicle'' or ''commercial heavy-duty on highway vehicle'' used in part 535. NHTSA is also adding a comma after the term ''fuel'' to indicate that it is a separate term from ''work truck.''

b. 49 CFR 535.7 Average, Banking, and Trading (ABT) Credit Program

NHTSA is amending § 535.7(a)(1)(iii) to remove outdated and unnecessary cross references. Specifically, the paragraph, which describes advanced technology credits, is being updated to remove reference to the credits being generated under EPA's regulations and instead will just reference NHTSA's relevant provisions at § 535.7(f)(1).

NHTSA is amending § 535.7(b)(2) to correct a cross-reference to the EPA's provision regarding fuel consumption values for advanced technologies. The current regulation references ''40 CFR 86.1819–14(d)(7)'' and NHTSA is correcting it read ''40 CFR 86.1819–14(d)(6)(iii).''

12. Technical Amendments to Part 536

NHTSA is making a technical amendment to part 536 to correct a date in Table 1 § 536.4(c)—Lifetime Vehicle Miles Traveled. The years covered in the final column of the table have been updated from ''2017–2026'' to ''2017–2031.'' This change is being made to reflect updates made in the Final Rulemaking for Model Years 2027–2031 Light-Duty Corporate Average Fuel Economy Standards.

13. Technical Amendments to Part 537

NHTSA is making a few technical amendments to part 537 to correct a typo and update statutory references to include the appropriate codified provisions.

a. 49 CFR 537.2 Scope

NHTSA is amending § 537.2 to correct a typo by changing ''valuating'' to ''evaluating.''

b. 49 CFR 537.3 Applicability

NHTSA is amending § 537.3 to replace the reference to ''section 502(c) of the Act'' to instead reference 49 U.S.C. 32902(d). This change is to aid the reader in finding the relevant statutory provision.

c. 49 CFR 537.4 Definitions

NHTSA is amending § 537.4 to change references to section 501 of the Motor Vehicle Information and Cost Savings Act, as amended by Public Law 94–163, to the appropriate codified provisions at 49 U.S.C. 32901. This change is to allow the reader to more easily identify the statutory definitions referenced in this section. With this change, NHTS is also removing the definition of *Act* as meaning the Motor Vehicle Information and Cost Savings Act (Pub. L. 92–513), as amended by the Energy Policy and Conservation Act (Pub. L. 94–163).

d. 49 CFR 537.7 Pre-Model Year and Mid-Model Year Reports

NHTSA is amending § 537.7(c)(7)(i), (ii), and (iii) to provide clarity and to note, in subparagraph (iii) that the reporting requirements for reporting full-size trucks that meet the mild and strong hybrid vehicle definitions end after model year 2024, to coincide with the sunset date for FCIVs for advanced full-size pickup trucks.

D. Non-Fuel Saving Credits or Flexibilities

In a comment to the August 16, 2022 EIS scoping notice for model year 2027 and beyond CAFE standards,[1620] Hyundai requested that NHTSA consider developing an optional credit program for vehicle manufacturers selling certain types of vehicles in environmental justice (EJ) communities.[1621] Because creation of any such program would be a part of NHTSA's CAFE Compliance and Enforcement program, NHTSA responded to Hyundai's comment in the proposal rather than in the EIS.[1622] NHTSA reaffirmed its commitment to considering communities with EJ concerns but declined to propose an EJ credit program in response to Hyundai's comment, for several reasons. In brief, NHTSA's concerns about Hyundai's proposed program included whether EPCA/EISA included the relevant authority to construct such a program, whether such a program would provide a credit windfall to manufacturers without providing verifiable benefits for communities with EJ concerns, and whether such a program would ensure EPCA/EISA's goal of saving fuel.

In comments responding to NHTSA's response, Hyundai proposed additional clarifications to their environmental justice proposal.[1623] Hyundai's concept, which they termed the Community Energy Savings Credit, would offer a maximum 25% discount on vehicles purchased by buyers with incomes at less than or equal to two times the Federal Poverty Level, if the buyers scrap an existing ICE vehicle that is at least ten model years old. Hyundai proposed credit earnings for the vehicles as follows: a 3x multiplier for HEVs and PHEVs, and a 5x multiplier for BEVs and FCEVs. The proposed program also includes annual OEM reporting requirements, in addition to OEM and scrappage companies being subject to agency audit.

NHTSA thanks Hyundai for thoughtfully responding to the concerns that NHTSA raised in the proposal. NHTSA will not create this type of credit program at this time. NHTSA has extensive experience administering a vehicle scrappage program,[1624] and is cognizant of the need to balance a program that achieves its stated goals against the program's administrative costs. NHTSA will continue to think of ways that EPCA/EISA and its other relevant authorities could allow the agency better consideration of EJ concerns in setting CAFE standards, beyond NHTSA's current

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[1620] Notice of Intent To Prepare an Environmental Impact Statement for MYs 2027 and Beyond Corporate Average Fuel Economy Standards and MYs 2029 and Beyond Heavy-Duty Pickup Trucks and Vans Vehicle Fuel Efficiency Improvement Program Standards (87 FR 50386).

[1621] Hyundai, Docket No. NHTSA–2022–0075–0011.

[1622] 88 FR 56372 (August 17, 2023).

[1623] Hyundai, Docket No. NHTSA–2023–0022–51701–A1, at 6–7.

[1624] Consumer Assistance to Recycle and Save Act of 2009 (CARS Program), *https://www.nhtsa.gov/fmvss/consumer-assistance-recycle-and-save-act-2009-cars-program.*

consideration.[1625] That said, NHTSA wants to emphasize that nothing in today's decision should preclude Hyundai specifically, and the automotive industry as a whole,[1626] from continuing to consider how it could better serve local communities, including those with EJ concerns. Aside from the potential to earn credits, NHTSA encourages automakers to deploy more fuel-efficient and cleaner vehicles in communities that have the potential to benefit from that deployment the most.

E. Additional Comments

NHTSA received many additional comments related to NHTSA's compliance programs for CAFE and fuel efficiency that requested changes that were either outside of the scope of this rulemaking or outside of NHTSA's statutory authority. Specifically, NHTSA received many comments on credit flexibilities for which NHTSA had not proposed any changes. Many of these flexibilities are set by statute and cannot be changed through NHTSA rulemaking. NHTSA discusses these comments below.

1. AC FCIVs

Some commenters may have misunderstood the proposal to phase out OC FCIVs and believed NHTSA was proposing changes to both AC and OC for ICE vehicles. Stellantis expressed concern that NHTSA was removing AC efficiencies for ICE.[1627] To be clear, NHTSA only proposed amending its regulations to note that OC FCIVs would be phased out. Therefore, phasing out FCIVs for AC efficiencies is out of scope of this rulemaking and the existing provisions for AC FCIVs for ICE vehicles will remain as is. Stellantis also requested additions to AC efficiencies for ICE vehicles.[1628] NHTSA didn't propose any changes to AC efficiencies for ICE vehicles for the NPRM, so this change would be outside the scope of this rulemaking.

2. Credit Transfer Cap AC

Several commenters requested that NHTSA adjust the transfer cap for credit transfers between fleets based on the oil savings equivalent to 2 mpg in 2018. In support of this request, the Auto Innovators urged NHTSA to ''interpret the statutory cap on credit transfers in terms of oil savings, a primary purpose of the CAFE program.'' [1629] Several other commenters expressed agreement and support for Auto Innovators' proposal. As part of the rationale supporting this request, several commenters expressed concerns that the transfer cap compounds the misalignment between NHTSA and EPA. Hyundai expressed their view that adjusting the transfer cap would support the Administration's goals of bringing green manufacturing to the United States by allowing credits earned in the DP fleet as a result of IRA tax credits incentivizing domestic production of BEVs to be used in the IP fleet.[1630] Ford commented stating that the ''[r]apid electrification of the light truck segment is much more expensive and difficult to achieve compared to passenger cars, and the transfer cap would limit its ability to use overcompliance in the Car fleet to meet the Truck fleet standards.[1631] And GM more generally recommended that NHTSA ''allow full fungibility of credits across regulated vehicle classes or otherwise adjust standard stringency, if vehicle classes have constraints that prevent alignment.'' [1632]

In response to these comments, NHTSA notes that the transfer cap is set by statute in 49 U.S.C. 32903(g)(3). NHTSA does not have the authority to adjust the transfer cap in a manner that is inconsistent with the plain language of the statute. For the final rule, NHTSA is not making any changes to the existing provisions regarding transferring credits. NHTSA's view remains unchanged that the transfer cap in 49 U.S.C. 32903(g)(1) clearly limits the amount of performance increase for a manufacturer's fleet that fails to achieve the prescribed standards. Accordingly, the statute prevents NHTSA from changing the transfer cap for CAFE compliance to be consistent with EPA's program.

3. Credit Trading Between HDPUV and Light Truck Fleets

Several commenters requested that NHTSA allow credit transfers between the HDPUV fleet and the light truck fleet. The Auto Innovators suggested that NHTSA create such transfer mechanism to ''address the likelihood of light trucks with heavy batteries moving to the Class 2b/3 fleet, and to improve alignment with proposed EPA regulations.'' [1633] The Auto Innovators assert that NHTSA's governing statutes do not prohibit it from creating a credit transfer program between HDPUVs and light truck fleets and suggested that NHTSA ''establish a transfer program from HDPUV to light truck by converting credits based on oil savings.'' [1634]

NHTSA disagrees with the Auto Innovators interpretation of the statute and instead believes that the statutes preclude NHTSA from establishing a transfer program from the HDPUV to the light truck fleet. Specifically, NHTSA notes that 49 U.S.C. 32912(b) establishes how NHTSA calculates penalties for violations of fuel economy standards and permits NHTSA to only consider the fuel economy calculated under 49 U.S.C. 32904(a)(1)(A) or (B) multiplied by the number of automobiles in the fleet and reduced by the credits available to the manufacturers under 49 U.S.C. 32903. Because credits for the HDPUV fleet would not be available to a manufacturer under 49 U.S.C. 32903, NHTSA would be precluded from considering those credits when evaluating whether a manufacturer complied with the fuel economy standards. Additionally, NHTSA notes that the authority for establishing requirements for light trucks and HDPUVs is provided under separate statutory provisions. NHTSA establishes requirements for light trucks pursuant to its authority for establishing CAFE standards at 49 U.S.C. 32902(b), whereas NHTSA's authority for establishing standards for fuel efficiency for HDPUVs comes from 49 U.S.C. 32902(k). Since the fuel economy and fuel efficiency programs are established under separate statutory provisions, NHTSA does not believe it has the authority to allow overcompliance in one program to offset shortfalls in the other.

4. Adjustment for Carry Forward and Carryback Credits

Honda commented about the devaluation of CAFE credits when they are used by a manufacturer to address its own future compliance shortfalls and requested that NHTSA adjust carryback and carry forward credits based on oil savings.[1635] Honda notes that while transferred or traded credits are appropriately adjusted into consumption-based equivalents before use, credits internally used within the

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[1625] *See, e.g.,* all past CAFE EISs, the current Final EIS, Chapter 7, and all past CAFE preambles.

[1626] See 88 FR 56371–2 (August 17, 2023). As far as NHTSA is aware, Hyundai was the first OEM commenter in CAFE history to comment about environmental justice.

[1627] Stellantis, Docket No. NHTSA–2023–0022–61107, at 9.

[1628] Stellantis, Docket No. NHTSA–2023–0022–61107, at 10.

[1629] The Alliance, NHTSA–2023–0022–60652, at 11–12.

[1630] HATCI, NHTSA–2023–0022–48991, at 2.

[1631] Ford, NHTSA–2023–022–60837, at 7.

[1632] GM, NHTSA–2023–0022–60686, at 5.

[1633] The Alliance, NHTSA–2023–0022–60652–A2, at 17.

[1634] The Alliance, NHTSA–2023–0022–60652–A2, at 13.

[1635] Honda, NHTSA–2023–0022–61033, at 7.

same compliance category are not similarly adjusted.[1636] For consistency with both GHG credits and traded CAFE credits, Honda requested that credits used similarly carry a gallons-equivalent value based on the achieved value, standard, and fleet-specific VMT under which they were earned. Honda stated that not adjusting the credits results in a devaluation of internally used credits, since credits earned under a less-efficient fleet represent a higher gallon-per-credit value and stated that it believes it is unlikely that Congress intended for such mathematical anomalies to persist in the CAFE average, banking, and trading (ABT) program.

NHTSA thanks Honda for their comment but notes that changes to carryback and carry forward credits are out of scope of this rulemaking. Accordingly, NHTSA is not making any changes in response to Honda's comment.

5. Increasing Carryback Period

HATCI commented requesting that NHTSA increase the carry-back period from 3 to 5 years.[1637] HATCI stated that extending the carryback period by two years would encourage manufacturers to develop long-term fuel economy increasing technologies.[1638] HATCI states that advanced technologies take years to develop, and the option to carry-back credits up to 5 years provides more opportunities for a return on R&D investments, which would support ZEV and high-MPG vehicle development.'' [1639]

In response to Hyundai-Kia's comment, NHTSA notes that the time period for carryback is set in statute at 49 U.S. Code 32903(a)(1). Accordingly, NHTSA does not have the authority to make any changes to the carryback period. NHTSA also notes that it considers the time of refresh and redesign of vehicles required for development of new technologies into consideration when setting standards. For more discussion on this see TSD Chapter 2.

6. Flex Fuel Vehicle Incentives

RFA *et al.,* 2 and MCGA requested that NHTSA and EPA reinstitute incentives for flex-fueled vehicles (FFVs).[1640] [1641] RFA *et al.* 2 also discussed how a lack of CAFE incentives for FFVs may have contributed to the decrease in FFVs from 2014 to 2021.

Per 49 U.S. Code 32906, the incentives for FFVs were phased out in model year 2020. While FFVs are still allowed to receive credits for exceeding CAFE standards under 49 U.S.C. 32903 based on EPA's calculation of fuel economy,[1642] but are no longer eligible for an increase in fuel economy under 49 U.S.C. 32906. EPA has existing provisions to calculate the emissions weighting of FFVs, based on our projection of actual usage of gasoline vs. E85, referred to as the F-factor.[1643] Additionally, as NHTSA did not propose any FFV incentives in the final rule, adopting new incentives would be outside the scope of this rulemaking. Accordingly, NHTSA is not making any changes regarding FFV incentives.

7. Reporting

Volkswagen commented requesting an alternative mechanism for reporting to reduce reporting burden.[1644] NHTSA thanks Volkswagen for its comment and would like to express its commitment to simplifying and streamlining reporting as much as possible. However, as NHTSA did not propose any changes to reporting in the NPRM, NHTSA will not be finalizing any changes to reporting at this time. NHTSA also notes that, as part of the previous CAFE rulemaking, it created templates for several of the required reports in order to simplify the reporting process and is open to continuing to work with manufacturers to simplify those reporting templates.

8. Petroleum Equivalency Factor for HDPUVs

In response to request on NHTSA's proposal to remove OC technology FCIVs for HDPUVs, several commenters seem to have misunderstood NHTSA's proposal and believed NHTSA intended to make changes to provision in the existing regulation that provides that BEVs and PHEVs are considered to have no fuel usage.[1645] However, NHTSA did not propose and will not be finalizing any changes to the zero g/mile assumption for compliance. Several commenters also requested that NHTSA establish petroleum equivalency values for HDPUVs to reflect the fact that BEVs do require energy.[1646] This request, however, is outside the scope of this rulemaking.

9. Incentives for Fuel Cell Electric Vehicles

BMW commented requesting additional incentives for hydrogen technology.[1647] BMW stated that they believe that ''hydrogen technology will play a key role on the path to climate neutrality across all industries and has great potential, particularly for individual mobility'' and asked NHTSA to consider additional incentives to support this nascent technology.[1648]

In response to BMW's comment, NHTSA notes that it did not propose any new incentives for vehicles with hydrogen technology and, therefore, any changes in this regard would be out of scope of the rulemaking. Additionally, BMW did not identify any specific authority that would allow NHTSA to create such new incentives and NHTSA has itself not identified statutory authority that would allow NHTSA to create new incentives. Accordingly, NHTSA is not finalizing any changes to add additional credit mechanisms for vehicles with hydrogen technology.

10. EV Development

GM commented suggesting that NHTSA and EPA create an optional compliance path for manufacturers that deliver ''greater-than-projected EV volumes for greater multipollutant and fuel consumption reduction.'' [1649] GM refers to this optional compliance path as a ''Leadership Pathway,'' and states that it believes that ''[a] voluntary program for companies with higher EV deployment has the potential to result in greater overall national EV volumes than the Executive Order 2030 goal (*i.e.,* 50% EVs)''.[1650]

In response to GM's comment, NHTSA notes that the agency did not propose any program to create new incentives for BEV production and, therefore, any such changes would be out of scope of this rulemaking. Additionally, NHTSA does not believe it has authority to establish the type of program GM describes.

11. PHEV in HDPUV

The Strong PHEV Coalition commented requesting incentives for HDPUV PHEVs. Specifically, the Strong PHEV Coalition requested incentives

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[1636] Honda, NHTSA–2023–0022–61033, at 7.

[1637] HATCI, NHTSA–2023–0022–48991, at 2.

[1638] HATCI, NHTSA–2023–0022–48991, at 2.

[1639] HATCI, NHTSA–2023–0022–48991, at 2.

[1640] RFA *et al.* 2, NHTSA–2023–0022–57625, at 18.

[1641] MCGA, NHTSA–2023–0022–60208, at 18.

[1642] 40 CFR 600.510–12(g).

[1643] 40 CFR 600.510–12(k) and 40 CFR 86.1819–14(d)(10)(i).

[1644] Volkswagen, NHTSA–2023–0022–58702, at 3.

[1645] Rivian, NHTSA–2023–0022–59765, at 10; Stellantis, NHTSA–2023–0022–61107–A1, at 12; The Aluminum Association, NHTSA–2023–0022–58486, at 3; ZETA, NHTSA–2023–0022–60508, at 29; Volkswagen, NHTSA–2023–0022–58702, at 4.

[1646] Valero, NHTSA–2023–0022–58547–G, at 6; The Aluminum Association, NHTSA–2023–0022–58486, at 3.

[1647] BMW, NHTSA–2023–0022–58614, at 4.

[1648] BMW, NHTSA–2023–0022–58614, at 4.

[1649] GM, NHTSA–2023–0022–60686, at 5.

[1650] GM, NHTSA–2023–0022–60686, at 5.

related to the use of the PHEV's battery to do work while the vehicle is stationary or to do bidirectional charging to the electric grid with on-board AC inverters. The Strong PHEV Coalition recommended that NHTSA ''somehow encourage these two technology types (*e.g.,* exemptions, advanced technology credit multiplier or some other type of special consideration) and include a robust discussion of these technologies.'' [1651]

Since NHTSA did not propose any incentives for HDPUVs PHEVs with special off-road functionality, any changes in response to this comment would be outside the scope of this rulemaking. Additionally, NHTSA does not believe its authority for establishing fuel efficiency standards would permit the agency to establish incentives related to off-road use of the vehicles. The discussed examples of bidirectional charging to the grid and charging of other electric machinery may be saving energy, but these savings are not related to energy use for transportation purposes.

VIII. Regulatory Notices and Analyses

A. Executive Order 12866, Executive Order 13563, and Executive Order 14094

E.O. 12866, ''Regulatory Planning and Review'' (58 FR 51735, Oct. 4, 1993), reaffirmed by E.O. 13563, ''Improving Regulation and Regulatory Review'' (76 FR 3821, Jan. 21, 2011), and amended by E.O. 14094, ''Modernizing Regulatory Review'' (88 FR 21879), provides for determining whether a regulatory action is ''significant'' and therefore subject to the Office of Management and Budget (OMB) review process and to the requirements of the E.O. Under these E.O.s, this action is a ''significant regulatory action'' under section 3(f)(1) of E.O. 12866, as amended by E.O. 14094, because it is likely to have an annual effect on the economy of $200 million or more. Accordingly, NHTSA submitted this action to OMB for review and any changes made in response to interagency feedback submitted via the OMB review process have been documented in the docket for this action. The estimated benefits and costs of this final rule are described above and in the FRIA, which is located in the docket and on NHTSA's website.

B. DOT Regulatory Policies and Procedures

This final rule is also significant within the meaning of the DOT's Regulatory Policies and Procedures. The estimated benefits and costs of the final rule are described above and in the FRIA, which is located in the docket and on NHTSA's website.

C. Executive Order 14037

E.O. 14037, ''Strengthening American Leadership in Clean Cars and Trucks'' (86 FR 43583, Aug. 10, 2021), directs the Secretary of Transportation (by delegation, NHTSA) to consider beginning work on a rulemaking under EISA to establish new fuel economy standards for passenger cars and LD trucks beginning with model year 2027 and extending through and including at least model year 2030, and to consider beginning work on a rulemaking under EISA to establish new fuel efficiency standards for HDPUVs beginning with model year 2028 and extending through and including at least model year 2030.[1652] The E.O. directs the Secretary to consider issuing any final rule no later than July 2024;[1653] to coordinate with the EPA and the Secretaries of Commerce, Labor, and Energy;[1654] and to, ''seek input from a diverse range of stakeholders, including representatives from labor unions, States, industry, environmental justice organizations, and public health experts.'' [1655]

This final rule follows the directions of this E.O. It is issued pursuant to NHTSA's statutory authorities as set forth in EISA and sets new CAFE standards for passenger cars and light trucks beginning in model year 2027, and new fuel efficiency standards for HDPUVs beginning in model year 2030 due to statutory lead time and stability requirements. NHTSA coordinated with EPA, Commerce, Labor, and Energy, in developing this final rule, and the final rule also accounts for the views provided by labor unions, States, industry, environmental justice organizations, and public health experts.

D. Environmental Considerations

1. National Environmental Policy Act (NEPA)

Concurrently with this final rule, NHTSA is releasing a Final EIS, pursuant to the National Environmental Policy Act, 42 U.S.C. 4321 *et seq.,* and implementing regulations issued by the Council on Environmental Quality (CEQ), 40 CFR parts 1500–1508, and NHTSA, 49 CFR part 520. NHTSA prepared the Final EIS to analyze and disclose the potential environmental impacts of the CAFE and HDPUV FE standards and a range of alternatives. The Final EIS analyzes direct, indirect, and cumulative impacts and analyzes impacts in proportion to their significance. It describes potential environmental impacts to a variety of resources, including fuel and energy use, air quality, climate, historical and cultural resources, and environmental justice. The Final EIS also describes how climate change resulting from global carbon dioxide emissions (including CO_2 emissions attributable to the U.S. LD and HDPUV transportation sectors under the alternatives considered) could affect certain key natural and human resources. Resource areas are assessed qualitatively and quantitatively, as appropriate, in the Final EIS.

NHTSA has considered the information contained in the Final EIS as part of developing this final rule.[1656] This preamble and final rule constitute the agency's Record of Decision (ROD) under 40 CFR 1505.2 for its promulgation of CAFE standards for model years 2027–2031 passenger cars and lights trucks and FE standards for model years 2030–2035 heavy-duty pickup trucks and vans. The agency has the authority to issue its Final EIS and ROD simultaneously pursuant to 49 U.S.C. 304a(b) and U.S. Department of Transportation, Office of Transportation Policy, *Guidance on the Use of Combined Final Environmental Impact Statements/Records of Decision and Errata Sheets in National Environmental Policy Act Reviews* (April 25, 2019).[1657] NHTSA has determined that neither the statutory criteria nor practicability considerations preclude simultaneous issuance. For additional information on NHTSA's NEPA analysis, please see the Final EIS.

As required by the CEQ regulations,[1658] this final rule (as the ROD) sets forth the following in Sections IV, V, and VI above: (1) the agency's decision; (2) alternatives considered by NHTSA in reaching its decision, including the environmentally preferable alternative; (3) the factors balanced by NHTSA in making its decision, including essential considerations of national policy (Section VIII.B above); (4) how these factors and considerations entered into its decision; and (5) the agency's

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[1651] Strong PHEV Coalition, NHTSA–2023–0022–60193, at 5.

[1652] 86 FR 43583 (Aug. 10, 2021), Sec. 2(b) and (c).

[1653] *Id.,* Sec. 5(b).

[1654] *Id.,* Sec. 6(a) and (b).

[1655] *Id.,* Sec. 6(d).

[1656] The Final EIS is available for review in the public docket for this action and in Docket No. NHTSA–2022–0075.

[1657] The guidance is available at *https://www.transportation.gov/sites/dot.gov/files/docs/mission/transportation-policy/permittingcenter/337371/feis-rod-guidance-final-04302019.pdf.*

[1658] 40 CFR 1505.2(a)(1) and (2).

preferences among alternatives based on relevant factors, including economic and technical considerations and agency statutory missions. The Final EIS discusses comments received on the Draft EIS, NHTSA's range of alternatives, and other factors used in the decision-making process. The Final EIS also addresses mitigation efforts as required by NEPA.[1659] NHTSA, as the lead agency, certifies that it has considered all of the alternatives, information, analyses, and objections submitted by cooperating agencies, and State, Tribal, and local governments and public commenters for consideration in developing the Final EIS, and that this final rule was informed by the summary of the submitted alternatives, information, and analyses in the Final EIS, together with any other material in the record that it has determined to be relevant.[1660]

2. Clean Air Act (CAA) as Applied to NHTSA's Final Rule

The CAA (42 U.S.C. 7401 *et seq.*) is the primary Federal legislation that addresses air quality. Under the authority of the CAA and subsequent amendments, EPA has established National Ambient Air Quality Standards (NAAQS) for six criteria pollutants, which are relatively commonplace pollutants that can accumulate in the atmosphere as a result of human activity. EPA is required to review NAAQS every five years and to revise those standards as may be appropriate considering new scientific information.

The air quality of a geographic region is usually assessed by comparing the levels of criteria air pollutants found in the ambient air to the levels established by the NAAQS (also considering the other elements of a NAAQS: averaging time, form, and indicator). Concentrations of criteria pollutants within the air mass of a region are measured in parts of a pollutant per million parts (ppm) of air or in micrograms of a pollutant per cubic meter (μg/m3) of air present in repeated air samples taken at designated monitoring locations using specified types of monitors. These ambient concentrations of each criteria pollutant are compared to the levels, averaging time, and form specified by the NAAQS to assess whether the region's air quality is in attainment with the NAAQS.

When the measured concentrations of a criteria pollutant within a geographic region are below those permitted by the NAAQS, EPA designates the region as an attainment area for that pollutant, while regions where concentrations of criteria pollutants exceed Federal standards are called nonattainment areas. Former nonattainment areas that are now in compliance with the NAAQS are designated as maintenance areas. Each State with a nonattainment area is required to develop and implement a State Implementation Plan (SIP) documenting how the region will reach attainment levels within the time periods specified in the CAA. For maintenance areas, the SIP must document how the State intends to maintain compliance with the NAAQS. EPA develops a Federal Implementation Plan (FIP) if a State fails to submit an approvable plan for attaining and maintaining the NAAQS. When EPA revises a NAAQS, each State must revise its SIP to address how it plans to attain the new standard.

No Federal agency may ''engage in, support in any way or provide financial assistance for, license or permit, or approve'' any activity that does not ''conform'' to a SIP or FIP after EPA has approved or promulgated it.[1661] Further, no Federal agency may ''approve, accept or fund'' any transportation plan, program, or project developed pursuant to Title 23 or Chapter 53 of Title 49, U.S.C., unless the plan, program, or project has been found to ''conform'' to any applicable implementation plan in effect.[1662] The purpose of these conformity requirements is to ensure that Federally sponsored or conducted activities do not interfere with meeting the emissions targets in SIPs or FIPs, do not cause or contribute to new violations of the NAAQS, and do not impede the ability of a State to attain or maintain the NAAQS or delay any interim milestones. EPA has issued two sets of regulations to implement the conformity requirements:

(1) The Transportation Conformity Rule [1663] applies to transportation plans, programs, and projects that are developed, funded, or approved under 23 U.S.C. (Highways) or 49 U.S.C. Chapter 53 (Public Transportation).

(2) The General Conformity Rule [1664] applies to all other Federal actions not covered under the Transportation Conformity Rule. The General Conformity Rule establishes emissions thresholds, or *de minimis* levels, for use in evaluating the conformity of an action that results in emissions increases.[1665] If the net increases of direct and indirect emissions exceed any of these thresholds, and the action is not otherwise exempt, then a conformity determination is required. The conformity determination can entail air quality modeling studies, consultation with EPA and state air quality agencies, and commitments to revise the SIP or to implement measures to mitigate air quality impacts.

The CAFE and HDPUV FE standards and associated program activities are not developed, funded, or approved under 23 U.S.C. or 49 U.S.C. Chapter 53. Accordingly, this final action and associated program activities would not be subject to transportation conformity. Under the General Conformity Rule, a conformity determination is required where a Federal action would result in total direct and indirect emissions of a criteria pollutant or precursor originating in nonattainment or maintenance areas equaling or exceeding the rates specified in 40 CFR 93.153(b)(1) and (2). As explained below, NHTSA's action results in neither direct nor indirect emissions as defined in 40 CFR 93.152.

The General Conformity Rule defines direct emissions as ''those emissions of a criteria pollutant or its precursors that are caused or initiated by the Federal action and originate in a nonattainment or maintenance area and occur at the same time and place as the action and are reasonably foreseeable.''[1666] NHTSA's action sets fuel economy standards for passenger cars and light trucks and fuel efficiency standards for HDPUVs. It therefore does not cause or initiate direct emissions consistent with the meaning of the General Conformity Rule.[1667] Indeed, the agency's action in aggregate reduces emissions, and to the degree the model predicts small (and time-limited) increases, these increases are based on a theoretical response by individuals to fuel prices and savings, which are at best indirect.

Indirect emissions under the General Conformity Rule are ''those emissions of a criteria pollutant or its precursors (1)

[1659] The CEQ regulations specify that a ROD must ''[s]tate whether the agency has adopted all practicable means to avoid or minimize environmental harm from the alternative selected, and if not, why the agency did not.'' 40 CFR 1505.2(a)(3). *See also* 40 CFR 1508.1(s) (''Mitigation includes . . . [m]inimizing impacts by limiting the degree or magnitude of the action and its implementation.'').

[1660] 40 CFR 1505.2(b).

[1661] 42 U.S.C. 7506(c)(1).

[1662] 42 U.S.C. 7506(c)(2).

[1663] 40 CFR part 51, subpart T, and part 93, subpart A.

[1664] 40 CFR part 51, subpart W, and part 93, subpart B.

[1665] 40 CFR 93.153(b).

[1666] 40 CFR 93.152.

[1667] *Dep't of Transp.* v. *Pub. Citizen,* 541 U.S. 752 at 772 (''[T]he emissions from the Mexican trucks are not 'direct' because they will not occur at the same time or at the same place as the promulgation of the regulations.''). NHTSA's action is to establish fuel economy standards for model year 2021–2026 passenger car and light trucks; any emissions increases would occur in a different place and well after promulgation of the final rule.

that are caused or initiated by the federal action and originate in the same nonattainment or maintenance area but occur at a different time or place as the action; (2) that are reasonably foreseeable; (3) that the agency can practically control; and (4) for which the agency has continuing program responsibility.''[1668] Each element of the definition must be met to qualify as indirect emissions. NHTSA has determined that, for purposes of general conformity, emissions (if any) that may result from its final fuel economy and fuel efficiency standards would not be caused by the agency's action, but rather would occur because of subsequent activities the agency cannot practically control. ''[E]ven if a Federal licensing, rulemaking or other approving action is a required initial step for a subsequent activity that causes emissions, such initial steps do not mean that a Federal agency can practically control any resulting emissions.''[1669]

As the CAFE and HDPUV FE programs use performance-based standards, NHTSA cannot control the technologies vehicle manufacturers use to improve the fuel economy of passenger cars and light trucks and fuel efficiency of HDPUVs. Furthermore, NHTSA cannot control consumer purchasing (which affects average achieved fleetwide fuel economy and fuel efficiency) and driving behavior (*i.e.,* operation of motor vehicles, as measured by VMT). It is the combination of fuel economy and fuel efficiency technologies, consumer purchasing, and driving behavior that results in criteria pollutant or precursor emissions. For purposes of analyzing the environmental impacts of the alternatives considered under NEPA, NHTSA has made assumptions regarding all of these factors. NHTSA's Final EIS projects that increases in air toxics and criteria pollutants would occur in some nonattainment areas under certain alternatives in the near term, although over the longer term, all action alternatives see improvements. However, the CAFE and HDPUV FE standards and alternative standards do not mandate specific manufacturer decisions, consumer purchasing, or driver behavior, and NHTSA cannot practically control any of them.[1670]

In addition, NHTSA does not have the statutory authority or practical ability to control the actual VMT by drivers. As the extent of emissions is directly dependent on the operation of motor vehicles, changes in any emissions that would result from NHTSA's CAFE and HDPUV FE standards are not changes NHTSA can practically control or for which NHTSA has continuing program responsibility. Therefore, the final CAFE and HDPUV FE standards and alternative standards considered by NHTSA would not cause indirect emissions under the General Conformity Rule, and a general conformity determination is not required.

3. National Historic Preservation Act (NHPA)

The NHPA (54 U.S.C. 300101 *et seq.*) sets forth government policy and procedures regarding ''historic properties''—that is, districts, sites, buildings, structures, and objects included on or eligible for the National Register of Historic Places. Section 106 of the NHPA requires Federal agencies to ''take into account'' the effects of their actions on historic properties.[1671] NHTSA concludes that the NHPA is not applicable to this rulemaking because the promulgation of CAFE standards for passenger cars and light trucks and FE standards for HDPUVs is not the type of activity that has the potential to cause effects on historic properties. However, NHTSA includes a brief, qualitative discussion of the impacts of the action alternatives on historical and cultural resources in the Final EIS.

4. Fish and Wildlife Conservation Act (FWCA)

The FWCA (16 U.S.C. 2901 *et seq.*) provides financial and technical assistance to States for the development, revision, and implementation of conservation plans and programs for nongame fish and wildlife. In addition, FWCA encourages all Federal departments and agencies to utilize their statutory and administrative authorities to conserve and to promote conservation of nongame fish and wildlife and their habitats. NHTSA concludes that the FWCA does not apply to this final rule because it does not involve the conservation of nongame fish and wildlife and their habitats. However, NHTSA conducted a qualitative review in its Final EIS of the related direct, indirect, and cumulative impacts, positive or negative, of the alternatives on potentially affected resources, including nongame fish and wildlife and their habitats.

5. Coastal Zone Management Act (CZMA)

The CZMA (16 U.S.C. 1451 *et seq.*) provides for the preservation, protection, development, and (where possible) restoration and enhancement of the Nation's coastal zone resources. Under the statute, States are provided with funds and technical assistance in developing coastal zone management programs. Each participating State must submit its program to the Secretary of Commerce for approval. Once the program has been approved, any activity of a Federal agency, either within or outside of the coastal zone, that affects any land or water use or natural resource of the coastal zone must be carried out in a manner that is consistent, to the maximum extent practicable, with the enforceable policies of the State's program.[1672]

NHTSA concludes that the CZMA does not apply to this rulemaking because it does not involve an activity within, or outside of, the nation's coastal zones that affects any land or water use or natural resource of the coastal zone. NHTSA has, however, conducted a qualitative review in the Final EIS of the related direct, indirect, and cumulative impacts, positive or negative, of the action alternatives on potentially affected resources, including coastal zones.

6. Endangered Species Act (ESA)

Under section 7(a)(2) of the ESA, Federal agencies must ensure that actions they authorize, fund, or carry out are ''not likely to jeopardize the continued existence'' of any Federally listed threatened or endangered species (collectively, ''listed species'') or result in the destruction or adverse modification of the designated critical habitat of these species.[1673] If a Federal agency determines that an agency action may affect a listed species or designated critical habitat, it must initiate consultation with the appropriate Service—the U.S. Fish and Wildlife Service (FWS) of the Department of the Interior (DOI) or the National Oceanic and Atmospheric Administration's National Marine Fisheries Service of the Department of Commerce (together, ''the Services'') or both, depending on the species involved—in order to ensure that the action is not likely to jeopardize the species or destroy or adversely modify designated critical habitat.[1674] Under this standard, the Federal agency taking action evaluates the possible

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[1668] 40 CFR 93.152.

[1669] 40 CFR 93.152.

[1670] *See, e.g., Dep't of Transp.* v. *Pub. Citizen,* 541 U.S. 752, 772–73 (2004); *S. Coast Air Quality Mgmt. Dist.* v. *Fed. Energy Regulatory Comm'n,* 621 F.3d 1085, 1101 (9th Cir. 2010).

[1671] Section 106 is now codified at 54 U.S.C. 306108. Implementing regulations for the section 106 process are located at 36 CFR part 800.

[1672] 16 U.S.C. 1456(c)(1)(A).

[1673] 16 U.S.C. 1536(a)(2).

[1674] *See* 50 CFR 402.14.

effects of its action and determines whether to initiate consultation.[1675]

The section 7(a)(2) implementing regulations require consultation if a Federal agency determines its action ''may affect'' listed species or critical habitat.[1676] The regulations define ''effects of the action'' as ''all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action but that are not part of the action.[1677] A consequence is caused by the proposed action if it would not occur *but for* the proposed action and it is *reasonably certain to occur.*'' [1678] The definition makes explicit a ''but for'' test and the concept of ''reasonably certain to occur'' for all effects.[1679] The Services have defined ''but for'' causation to mean ''that the consequence in question would not occur if the proposed action did not go forward. . . In other words, if the agency fails to take the proposed action and the activity would still occur, there is no 'but for' causation. In that event, the activity would not be considered an effect of the action under consultation.''[1680]

The Services have previously provided legal and technical guidance about whether CO_2 emissions associated with a specific proposed Federal action trigger ESA section 7(a)(2) consultation. NHTSA analyzed the Services' history of actions, analysis, and guidance in Appendix G of the model year 2012–2016 CAFE standards EIS and now adopts by reference that appendix here.[1681] In that appendix, NHTSA looked at the history of the Polar Bear Special Rule and several guidance memoranda provided by FWS and the U.S. Geological Survey. Ultimately, DOI concluded that a causal link could not be made between CO_2 emissions associated with a proposed Federal action and specific effects on listed species; therefore, no section 7(a)(2) consultation would be required.

Subsequent to the publication of that appendix, a court vacated the Polar Bear Special Rule on NEPA grounds, though it upheld the ESA analysis as having a rational basis.[1682] FWS then issued a revised Final Special Rule for the Polar Bear.[1683] In that final rule, FWS provided that for ESA section 7, the determination of whether consultation is triggered is narrow and focused on the discrete effect of the proposed agency action. FWS wrote, ''[T]he consultation requirement is triggered only if there is a causal connection between the proposed action and a discernible effect to the species or critical habitat that is reasonably certain to occur. One must be able to 'connect the dots' between an effect of a proposed action and an impact to the species and there must be a reasonable certainty that the effect will occur.'' [1684] The statement in the revised Final Special Rule is consistent with the prior guidance published by FWS and remains valid today.[1685] If the consequence is not reasonably certain to occur, it is not an ''effect of a proposed action'' and does not trigger the consultation requirement.

In this NPRM for this action, NHTSA stated that pursuant to section 7(a)(2) of the ESA, NHTSA considered the effects of the proposed CAFE and HDPUV FE standards and reviewed applicable ESA regulations, case law, and guidance to determine what, if any, impact there might be to listed species or designated critical habitat. NHTSA considered issues related to emissions of CO_2 and other GHGs, and issues related to non-GHG emissions. NHTSA stated that, based on this assessment, the agency determined that the action of setting CAFE and HDPUV FE standards does not require consultation under section 7(a)(2) of the ESA. NHTSA's determination remains unchanged from the NPRM and has concluded the agency's review of this action under section 7 of the ESA.

7. Floodplain Management (Executive Order 11988 and DOT Order 5650.2)

These Orders require Federal agencies to avoid the long- and short-term adverse impacts associated with the occupancy and modification of floodplains, and to restore and preserve the natural and beneficial values served by floodplains. E.O. 11988, ''Floodplain management'' (May 24, 1977), also directs agencies to minimize the impacts of floods on human safety, health and welfare, and to restore and preserve the natural and beneficial values served by floodplains through evaluating the potential effects of any actions the agency may take in a floodplain and ensuring that its program planning and budget requests reflect consideration of flood hazards and floodplain management. DOT Order 5650.2, ''Floodplain Management and Protection'' (April 23, 1979), sets forth DOT policies and procedures for implementing E.O. 11988. The DOT Order requires that the agency determine if a proposed action is within the limits of a base floodplain, meaning it is encroaching on the floodplain, and whether this encroachment is significant. If significant, the agency is required to conduct further analysis of the proposed action and any practicable alternatives. If a practicable alternative avoids floodplain encroachment, then the agency is required to implement it.

In this final rule, NHTSA is not occupying, modifying, and/or encroaching on floodplains. NHTSA therefore concludes that the Orders do not apply to this final rule. NHTSA has, however, conducted a review of the alternatives on potentially affected resources, including floodplains, in its Final EIS.

8. Preservation of the Nation's Wetlands (Executive Order 11990 and DOT Order 5660.1a)

These Orders require Federal agencies to avoid, to the extent possible, undertaking or providing assistance for new construction located in wetlands

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[1675] *See* 50 CFR 402.14(a) (''Each Federal agency shall review its actions at the earliest possible time to determine whether any action may affect listed species or critical habitat.'').

[1676] 50 CFR 402.14(a).

[1677] On April 5, 2024, the Services issued revised ESA consultation regulations. 89 FR 24268 (revisions to portions of regulations that implement section 7 of the Endangered Species Act of 1973, as amended). Among other amendments, the Services updated the definition of ''effects of action'' by adding the phrase ''but that are not part of the action'' to clarify that the scope of the analysis of the effects includes other activities caused by the proposed action that are reasonably certain to occur. *Id.* at 24273.

[1678] 50 CFR 402.02 (emphasis added).

[1679] The Services' prior regulations defined ''effects of the action'' in relevant part as ''the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline.'' 50 CFR 402.02 (as in effect prior to Oct. 28, 2019). Indirect effects were defined as ''those that are caused by the proposed action and are later in time, but still are reasonably certain to occur.'' *Id.*

[1680] 84 FR 44977 (Aug. 27, 2019) (''As discussed in the proposed rule, the Services have applied the 'but for' test to determine causation for decades. That is, we have looked at the consequences of an action and used the causation standard of 'but for' plus an element of foreseeability (*i.e.,* reasonably certain to occur) to determine whether the consequence was caused by the action under consultation.''). We note that as the Services do not consider this to be a change in their longstanding application of the ESA, this interpretation applies equally under the prior regulations (which were effective through October 28, 2019) and the current regulations (as amended on April 5, 2024). *See* 89 FR 24268.

[1681] Available on NHTSA's Corporate Average Fuel Economy website at *https://static.nhtsa.gov/nhtsa/downloads/CAFE/2012-2016%20Docs-PCLT/2012-2016%20Final%20Environmental%20Impact%20Statement/Appendix_G_Endangered_Species_Act_Consideration.pdf.*

[1682] *In re: Polar Bear Endangered Species Act Listing and Section 4(D) Rule Litigation,* 818 F.Supp.2d 214 (D.D.C. Oct. 17, 2011).

[1683] 78 FR 11766 (Feb. 20, 2013).

[1684] 78 FR 11784–11785 (Feb. 20, 2013).

[1685] See DOI. 2008. Guidance on the Applicability of the Endangered Species Act Consultation Requirements to Proposed Actions Involving the Emissions of Greenhouse Gases. Solicitor's Opinion No. M–37017. Oct. 3, 2008.

unless the agency head finds that there is no practicable alternative to such construction and that the proposed action includes all practicable measures to minimize harms to wetlands that may result from such use. E.O. 11990, ''Protection of Wetlands'' (May 24, 1977), also directs agencies to take action to minimize the destruction, loss, or degradation of wetlands in ''conducting Federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulating, and licensing activities.'' DOT Order 5660.1a, ''Preservation of the Nation's Wetlands'' (August 24, 1978), sets forth DOT policy for interpreting E.O. 11990 and requires that transportation projects ''located in or having an impact on wetlands'' should be conducted to assure protection of the Nation's wetlands. If a project does have a significant impact on wetlands, an EIS must be prepared.

NHTSA is not undertaking or providing assistance for new construction located in wetlands. NHTSA therefore concludes that these Orders do not apply to this rulemaking. NHTSA has, however, conducted a review of the alternatives on potentially affected resources, including wetlands, in its Final EIS.

9. Migratory Bird Treaty Act (MBTA), Bald and Golden Eagle Protection Act (BGEPA), Executive Order 13186

The MBTA (16 U.S.C. 703–712) provides for the protection of certain migratory birds by making it illegal for anyone to ''pursue, hunt, take, capture, kill, attempt to take, capture, or kill, possess, offer for sale, sell, offer to barter, barter, offer to purchase, purchase, deliver for shipment, ship, export, import, cause to be shipped, exported, or imported, deliver for transportation, transport or cause to be transported, carry or cause to be carried, or receive for shipment, transportation, carriage, or export'' any migratory bird covered under the statute.[1686]

The BGEPA (16 U.S.C. 668–668d) makes it illegal to ''take, possess, sell, purchase, barter, offer to sell, purchase or barter, transport, export or import'' any bald or golden eagles.[1687] E.O. 13186, ''Responsibilities of Federal Agencies to Protect Migratory Birds,'' helps to further the purposes of the MBTA by requiring a Federal agency to develop an MOU with FWS when it is taking an action that has (or is likely to have) a measurable negative impact on migratory bird populations.

NHTSA concludes that the MBTA, BGEPA, and E.O. 13186 do not apply to this rulemaking because there is no disturbance, take, measurable negative impact, or other covered activity involving migratory birds or bald or golden eagles involved in this rulemaking.

10. Department of Transportation Act (Section 4(f))

Section 4(f) of the Department of Transportation Act of 1966 (49 U.S.C. 303), as amended, is designed to preserve publicly owned park and recreation lands, waterfowl and wildlife refuges, and historic sites. Specifically, section 4(f) provides that DOT agencies cannot approve a transportation program or project that requires the use of any publicly owned land from a public park, recreation area, or wildlife or waterfowl refuge of national, State, or local significance, unless a determination is made that:

(1) There is no feasible and prudent alternative to the use of land, and

(2) The program or project includes all possible planning to minimize harm to the property resulting from the use.

These requirements may be satisfied if the transportation use of a section 4(f) property results in a de minimis impact on the area.

NHTSA concludes that section 4(f) does not apply to this rulemaking because this rulemaking is not an approval of a transportation program nor project that requires the use of any publicly owned land.

11. Executive Order 12898: ''Federal Actions To Address Environmental Justice in Minority Populations and Low-Income Populations''; Executive Order 14096: ''Revitalizing Our Nation's Commitment to Environmental Justice for All''

E.O. 12898, ''*Federal Actions to Address EJ in Minority Populations and Low-Income Populations*'' (Feb. 16, 1994), directs Federal agencies to promote nondiscrimination in federal programs substantially affecting human health and the environment, and provide minority and low-income communities access to public information on, and an opportunity for public participation in, matters relating to human health or the environment. E.O. 14096, ''*Revitalizing Our Nation's Commitment to Environmental Justice for All,*'' (April 21, 2023), builds on and supplements E.O. 12898, and further directs Federal agencies to prioritize EJ initiatives in their core missions.[1688] Additionally, the 2021 DOT Order 5610.2C, ''U.S. Department of Transportation Actions to Address Environmental Justice in Minority Populations and Low-Income Populations'' (May 16, 2021), describes the process for DOT agencies to incorporate EJ principles in programs, policies, and activities. Section VI and the Final EIS discuss NHTSA's consideration of EJ issues associated with this final rule.

12. Executive Order 13045: ''Protection of Children From Environmental Health Risks and Safety Risks''

This action is subject to E.O. 13045 (62 FR 19885, Apr. 23, 1997) because is a significant regulatory action under section 3(f)(1) of E.O. 12866, and NHTSA has reason to believe that the environmental health and safety risks related to this action, although small, may have a disproportionate effect on children. Specifically, children are more vulnerable to adverse health effects related to mobile source emissions, as well as to the potential long-term impacts of climate change. Pursuant to E.O. 13045, NHTSA must prepare an evaluation of the environmental health or safety effects of the planned action on children and an explanation of why the planned action is preferable to other potentially effective and reasonably feasible alternatives considered by NHTSA. Further, this analysis may be included as part of any other required analysis.

All of the action alternatives would reduce CO_2 emissions relative to the reference baseline and thus have positive effects on mitigating global climate change, and thus environmental and health effects associated with climate change. While environmental and health effects associated with criteria pollutant and toxic air pollutant emissions vary over time and across alternatives, negative effects, when estimated, are extremely small. This preamble and the Final EIS discuss air quality, climate change, and their related environmental and health effects. In addition, Section VI of this preamble explains why NHTSA believes that the CAFE and HDPUV FE final standards are preferable to other alternatives considered. Together, this

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[1686] 16 U.S.C. 703(a).

[1687] 16 U.S.C. 668(a).

[1688] E.O. 14096 on environmental justice does not rescind E.O. 12898—''Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations,'' which has been in effect since February 11, 1994 and is currently implemented through DOT Order 5610.2C. This implementation will continue until further guidance is provided regarding the implementation of the new E.O. 14096 on environmental justice.

preamble and Final EIS satisfy NHTSA's responsibilities under E.O. 13045.

E. Regulatory Flexibility Act

Pursuant to the Regulatory Flexibility Act (5 U.S.C. 601 *et seq.,* as amended by the Small Business Regulatory Enforcement Fairness Act (SBREFA) of 1996), whenever an agency is required to publish a NPRM or final rule, it must prepare and make available for public comment a regulatory flexibility analysis that describes the effect of the rule on small entities (*i.e.,* small businesses, small organizations, and small governmental jurisdictions). No regulatory flexibility analysis is required if the head of an agency certifies the rule will not have a significant economic impact on a substantial number of small entities. SBREFA amended the Regulatory Flexibility Act to require Federal agencies to provide a statement of the factual basis for certifying that a rule will not have a significant economic impact on a substantial number of small entities.

NHTSA has considered the impacts of this final rule under the Regulatory Flexibility Act and the head of NHTSA certifies that this final rule will not have a significant economic impact on a substantial number of small entities. The following is NHTSA's statement providing the factual basis for this certification pursuant to 5 U.S.C. 605(b).

Small businesses are defined based on the North American Industry Classification System (NAICS) code.[1689] One of the criteria for determining size is the number of employees in the firm. For establishments primarily engaged in manufacturing or assembling automobiles, including HDPUVs, the firm must have less than 1,500 employees to be classified as a small business. This rulemaking would affect motor vehicle manufacturers. As shown in Table VII–1, NHTSA has identified eighteen small manufacturers that produce passenger cars, light trucks, SUVs, HD pickup trucks, and vans of electric, hybrid, and ICEs. NHTSA acknowledges that some very new manufacturers may potentially not be listed. However, those new manufacturers tend to have transportation products that are not part of the LD and HDPUV vehicle fleet and have yet to start production of relevant vehicles. Moreover, NHTSA does not believe that there are a ''substantial number'' of these companies.[1690]

Table VIII-1: Small Domestic Manufacturers

Manufacturers	Founded	Employees[1691]	Estimated Annual Production[1692]
Anteros Coachworks	2005	< 25	< 100
Aptera	2006	51	0
BXR Motors	2007	< 25	< 100
Canoo (HDPUV)	2018	812	< 100
Equus Automotive	2008	< 25	< 100
Falcon Motorsports	2009	< 25	< 100
Faraday Future (HDPUV)	2014	600	<100
Fisker (HDPUV)	2016	985	< 500
Hennessey Performance	1991	55	< 100
Lucra Cars	2005	< 25	< 100
Lyons Motor Car	2012	< 25	< 100
Panoz	1988	< 50	< 100
RAESR	2013	< 25	< 100
Rezvani Motors	2014	< 25	< 100
Rossion Automotive	2007	< 50	< 100
Saleen Automotive, Inc.	1984	81	< 100
Shelby American	1962	< 100	< 100
SSC Automotive	1999	< 25	< 100

NHTSA believes that the final rule would not have a significant economic impact on small vehicle manufacturers, because under 49 CFR part 525 passenger car manufacturers building less than 10,000 vehicles per year can petition NHTSA to have alternative standards determined for them. Listed manufacturers producing ICE vehicles

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[1689] Classified in NAICS under Subsector 336—Transportation Equipment Manufacturing for Automobile and Light Duty Motor Vehicle Manufacturing (336110) and Heavy Duty Truck Manufacturing (336120). Available at: *https://www.sba.gov/document/support--table-size-standards.* (last accessed Feb. 22, 2024).

[1690] 5 U.S.C. 605(b).

[1691] Estimated number of employees as of February 2024, source: *linkedin.com, zoominfo.com, rocketreach.co, and datanyze.com.*

[1692] Rough estimate of LDV production for model year 2022.

do not currently meet the standard and must already petition NHTSA for relief. If the standard is raised, it has no meaningful impact on these manufacturers—they still must go through the same process and petition for relief. Given there already is a mechanism for relieving burden on small businesses, a regulatory flexibility analysis was not prepared.

All HDPUV manufacturers listed in Table VIII–1 build BEVs, and consequently far exceed the fuel efficiency standards. We designate those vehicles to have no fuel consumption. NHTSA has researched the HDPUV manufacturing industry and found no small manufacturers of ICE vehicles that would be impacted by the final rule.

Further, small manufacturers of EVs would not face a significant economic impact. The method for earning credits applies equally across manufacturers and does not place small entities at a significant competitive disadvantage. In any event, even if the rulemaking had a ''significant economic impact'' on these small EV manufacturers, the number of these companies is not ''a substantial number.'' [1693] For these reasons, their existence does not alter NHTSA's analysis of the applicability of the Regulatory Flexibility Act.

F. Executive Order 13132 (Federalism)

E.O. 13132, ''Federalism'' (64 FR 43255, Aug. 10, 1999), requires Federal agencies to develop an accountable process to ensure ''meaningful and timely input by State and local officials in the development of regulatory policies that have federalism implications.'' The order defines the term ''[p]olicies that have federalism implications'' to include regulations that have ''substantial direct effects on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government.'' Under the order, agencies may not issue a regulation that has federalism implications, that imposes substantial direct compliance costs, unless the Federal Government provides the funds necessary to pay the direct compliance costs incurred by the State and local governments, or the agencies consult with State and local officials early in the process of developing the final rule.

Similar to the CAFE preemption final rule,[1694] NHTSA continues to believe that this final rule does not implicate E.O. 13132, because it neither imposes substantial direct compliance costs on State, local, or Tribal governments, nor does it preempt State law. Thus, this final rule does not implicate the consultation procedures that E.O. 13132 imposes on agency regulations that would either preempt State law or impose substantial direct compliance costs on State, local, or Tribal governments, because the only entities subject to this final rule are vehicle manufacturers. Nevertheless, NHTSA has complied with the Order's requirements and consulted directly with CARB in developing a number of elements of this final rule.

A few commenters (a comment from several states led by West Virginia,[1695] Valero,[1696] CEI,[1697] a group of organizations by led by the Renewable Fuels Association (RFA),[1698] and a group of organizations led by the Clean Fuels Development Coalition [1699]), though, claimed that this rule raised preemption issues, specifically NHTSA's consideration of California's ZEV program in the reference baseline and out years. In particular, these commenters believed that the ZEV program is a ''law or regulation related to fuel economy standards'' and, thus, preempted under section 32919(a).[1700] A few of these commenters referenced NHTSA's 2019 attempt to dictate the contours EPCA preemption through the SAFE I rule, and criticized the agency's subsequent repeal of that rule. In particular, those commenters advocated for NHTSA to make a substantive determination of whether state programs are preempted by EPCA.[1701]

NHTSA is not taking any action regarding preemption in this final rule, as this rule's purpose is to establish new final CAFE and HDPUV standards. Nothing in EPCA or EISA provides that NHTSA must, or even should, make a determination or pronouncement on preemption.[1702] As such, the agency continues to believe that it is not appropriate to opine in a sweeping manner on the legality of State programs—particularly in a generalized rulemaking. Moreover, this type of legal determination is unnecessary for this action because the agency's decision to incorporate the ZEV program is not based on an assessment of its legality, but rather the agency's empirical observation that the program seems likely to have an actual impact on the compositions of vehicle fleets in California and other states that adopt similar programs. To date, a court has not determined that this program is preempted by EPCA. In fact, the D.C. Circuit recently rejected consolidated challenges to the EPA's waiver to CARB for the Advanced Clean Car Program.[1703] As a result, California programs and those of other states appear likely to remain in place at least long enough to influence fleet composition decisions by vehicle manufacturers over the relevant timeframes for this rule's analysis. Should future changes in the legal status of those programs occur, NHTSA would, of course, adjust its analysis as needed to reflect the likely empirical effects of such developments. Separately, RFA and the Clean Fuels Development Coalition also argued that the renewable fuel standards (RFS) program preempts the ZEV program.[1704] [1705] NHTSA does not administer this program but notes that the ZEV program has never been found to be preempted by the RFS and thus, the program, as a factual matter, is not preempted. Therefore, much like their EPCA preemption arguments, the commenters' RFS preemption arguments also do not change the empirical effect that the ZEV program has on manufacturers' decisions and projections about the compositions of their fleets.

G. Executive Order 12988 (Civil Justice Reform)

Pursuant to E.O. 12988, ''Civil Justice Reform'' (61 FR 4729, Feb. 7, 1996), NHTSA has considered whether this final rule would have any retroactive effect. This final rule does not have any retroactive effect.

[1693] 5 U.S.C. 605.

[1694] *See* 86 FR 74236, 74365 (Dec. 29, 2021).

[1695] West Virginia Attorney General's Office, Docket No. NHTSA–2023–0022–63056 at 9–10.

[1696] Valero, Docket No. NHTSA–2023–0022–58547 at 13.

[1697] CEI, Docket No. NHTSA–2023–0022–61121 at 8.

[1698] RFA et al, Docket No. NHTSA–2023–0022–57625 at 12.

[1699] CFDC et al, NHTSA–2023–0022–62242 at 6.

[1700] *See, e.g,.* West Virginia Attorney General's Office, Docket No. NHTSA–2023–0022–63056 at 9 (''ZEV programs relate to fuel economy standards, so incorporating them into the Proposed Rule turns Congress's preemption judgment upside down.''); Valero, NHTSA–2023–0022–58547 at 13 (''the state ZEV mandates that NHTSA incorporated into its regulatory baseline are independently unlawful under EPCA's preemption provision.'').

[1701] West Virginia Attorney General's Office, Docket No. NHTSA–2023–0022–63056 at 9 (''So one would think that California's program and others like it are 'related to' fuel economy standards. But the agency refuses to 'tak[e] a position on whether' ZEV 'programs are preempted' here. . . . NHTSA is wrong.'')

[1702] *See, e.g.,* NHTSA, Final Rule: *CAFE Preemption,* 86 FR 74,236, 74,241 (Dec. 29, 2021).

[1703] *Ohio* v. *EPA,* No. 22–1081 (D.C. Cir. Sept. 15, 2023).

[1704] RFA et al, NHTSA–2023–0022–57625 at 12.

[1705] CFDC et al, NHTSA–2023–0022–62242 at 6.

H. Executive Order 13175 (Consultation and Coordination With Indian Tribal Governments)

This final rule does not have tribal implications, as specified in E.O. 13175, ''Consultation and Coordination with Indian Tribal Governments'' (65 FR 67249, Nov. 9, 2000). This final rule would be implemented at the Federal level and would impose compliance costs only on vehicle manufacturers. Thus, E.O. 13175, which requires consultation with Tribal officials when agencies are developing policies that have ''substantial direct effects'' on Tribes and Tribal interests, does not apply to this final rule.

I. Unfunded Mandates Reform Act

Section 202 of the Unfunded Mandates Reform Act of 1995 (UMRA) requires Federal agencies to prepare a written assessment of the costs, benefits, and other effects of a proposed or final rule that includes a Federal mandate likely to result in the expenditure by State, local, or Tribal governments, in the aggregate, or by the private sector, of more than $100 million in any one year (adjusted for inflation with base year of 1995). Adjusting this amount by the implicit gross domestic product price deflator for 2021 results in $165 million (110.213/66.939 = 1.65).[1706] Before promulgating a rule for which a written statement is needed, section 205 of UMRA generally requires NHTSA to identify and consider a reasonable number of regulatory alternatives and adopt the least costly, most cost-effective, or least burdensome alternative that achieves the objective of the rule. The provisions of section 205 do not apply when they are inconsistent with applicable law. Moreover, section 205 allows NHTSA to adopt an alternative other than the least costly, most cost-effective, or least burdensome alternative if NHTSA publishes with the rule an explanation of why that alternative was not adopted.

This final rule will not result in the expenditure by State, local, or Tribal governments, in the aggregate, of more than $165 million annually, but it will result in the expenditure of that magnitude by vehicle manufacturers and/or their suppliers. In developing this final rule, we considered a range of alternative fuel economy and fuel efficiency standards. As explained in detail in Section V of the preamble above, NHTSA concludes that our selected alternatives are the maximum feasible alternatives that achieve the objectives of this rulemaking, as required by EPCA/EISA.

J. Regulation Identifier Number

The DOT assigns a regulation identifier number (RIN) to each regulatory action listed in the Unified Agenda of Federal Regulations. The Regulatory Information Service Center publishes the Unified Agenda in April and October of each year. The RIN contained in the heading at the beginning of this document may be used to find this action in the Unified Agenda.

K. National Technology Transfer and Advancement Act

Section 12(d) of the National Technology Transfer and Advancement Act (NTTAA) requires NHTSA evaluate and use existing voluntary consensus standards in its regulatory activities unless doing so would be inconsistent with applicable law (*e.g.,* the statutory provisions regarding NHTSA's vehicle safety authority) or otherwise impractical.[1707]

Voluntary consensus standards are technical standards developed or adopted by voluntary consensus standards bodies. Technical standards are defined by the NTTAA as ''performance-based or design-specific technical specification and related management systems practices.'' They pertain to ''products and processes, such as size, strength, or technical performance of a product, process or material.''

Examples of organizations generally regarded as voluntary consensus standards bodies include the American Society for Testing and Materials, International, the SAE, and the American National Standards Institute (ANSI). If NHTSA does not use available and potentially applicable voluntary consensus standards, it is required by the Act to provide Congress, through OMB, an explanation of reasons for not using such standards. There are currently no consensus standards that NHTSA administers relevant to these CAFE and HDPUV standards.

L. Department of Energy Review

In accordance with 49 U.S.C. 32902(j)(2), NHTSA submitted this final rule to the DOE for review. That agency did not make any comments that NHTSA did not address.[1708]

M. Paperwork Reduction Act

Under the procedures established by the Paperwork Reduction Act of 1995 (PRA) (44 U.S.C. 3501, *et seq.*), Federal agencies must obtain approval from the OMB for each collection of information they conduct, sponsor, or require through regulations. A person is not required to respond to a collection of information by a Federal Agency unless the collection displays a valid OMB control number. This final rule implements changes that relate to information collections that are subject to the PRA, but the changes are not expected to substantially or materially modify the information collections nor increase the burden associated with the information collections. Additional details about NHTSA's information collection for its Corporate Average Fuel Economy (CAFE) program (OMB control number 2127–0019, Current Expiration: 02/28/2026) and how NHTSA estimated burden for this collection are available in the supporting statements for the currently approved collection.[1709]

N. Congressional Review Act

The Congressional Review Act, 5 U.S.C. 801 *et seq.*, as added by the Small Business Regulatory Enforcement Fairness Act of 1996, generally provides that before a rule may take effect, the agency promulgating the rule must submit a rule report, which includes a copy of the rule, to each House of the Congress and to the Comptroller General of the United States. NHTSA will submit a report containing this rule and other required information to the U.S. Senate, the U.S. House of Representatives, and the Comptroller General of the United States prior to publication of the rule in the **Federal Register**. Because this rule meets the criteria in 5 U.S.C. 804(2), it will be effective sixty days after the date of publication in the **Federal Register**.

List of Subjects in 49 CFR Parts 523, 531, 533, 535, 536 and 537

Fuel economy, Reporting and recordkeeping requirements.

For the reasons discussed in the preamble, NHTSA is amending 49 CFR parts 523, 531, 533, 535, 536, and 537 as follows:

PART 523—VEHICLE CLASSIFICATION

■ 1. The citation for part 523 continues to read as follows:

[1706] U.S. Bureau of Economic Analysis (BEA). 2024. National Income and Product Accounts, Table 1.1.9: Implicit Price Deflators for Gross Domestic Product (use Interactive Data Tables to select years). Available at: *https://apps.bea.gov/iTable/?reqid=19&step=2&isuri=1&categories=survey.* (Accessed: Feb, 28, 2024).

[1707] 15 U.S.C. 272.

[1708] DOE's letter of review of the final rule.

[1709] Office of Information and Regulatory Affairs. 2022. Supporting Statements: Part A, Corporate Average Fuel Economy Reporting. OMB 2127–0019. Available at: *https://www.reginfo.gov/public/do/PRAViewDocument?ref_nbr=202210-2127-003.* (Accessed: Feb, 28, 2024).

Authority: 49 U.S.C. 32901; delegation of authority at 49 CFR 1.95.

■ 2. Amend § 523.2 by revising the definitions of ''Base tire (for passenger automobiles, light trucks, and medium-duty passenger vehicles)'', ''Basic vehicle frontal area'', ''Emergency vehicle'', ''Full-size pickup truck'', ''Light truck'', and ''Medium duty passenger vehicle'' to read as follows:

§ 523.2 Definitions.

* * * * *

Base tire (for passenger automobiles, light trucks, and medium-duty passenger vehicles) means the tire size specified as standard equipment by the manufacturer on each unique combination of a vehicle's footprint and model type. Standard equipment is defined in 40 CFR 86.1803.

Basic vehicle frontal area is used as defined in 40 CFR 86.1803–01 for passenger automobiles, light trucks, medium-duty passenger vehicles and Class 2b through 3 pickup trucks and vans. For heavy-duty tracts and vocational vehicles, it has the meaning given in 40 CFR 1037.801.

* * * * *

Emergency vehicle means one of the following:

(1) For passenger cars, light trucks and medium-duty passenger vehicles, emergency vehicle has the meaning given in 49 U.S.C. 32902(e).

(2) For heavy-duty vehicles, emergency vehicle has the meaning given in 40 CFR 1037.801.

* * * * *

Full-size pickup truck means a light truck, including a medium-duty passenger vehicle, that meets the specifications in 40 CFR 86.1803–01 for a full-size pickup truck.

* * * * *

Light truck means a non-passenger automobile meeting the criteria in § 523.5. The term light truck includes medium-duty passenger vehicles that meet the criteria in § 523.5 for non-passenger automobiles.

* * * * *

Medium-duty passenger vehicle means any complete or incomplete motor vehicle rated at more than 8,500 pounds GVWR and less than 10,000 pounds GVWR that is designed primarily to transport passengers, but does not include a vehicle that—

(1) Is an ''incomplete truck,'' meaning any truck which does not have the primary load carrying device or container attached; or

(2) Has a seating capacity of more than 12 persons; or

(3) Is designed for more than 9 persons in seating rearward of the driver's seat; or

(4) Is equipped with an open cargo area (for example, a pick-up truck box or bed) of 72.0 inches in interior length or more. A covered box not readily accessible from the passenger compartment will be considered an open cargo area for purposes of this definition. (See paragraph (1) of the definition of *medium-duty passenger vehicle* at 40 CFR 86.1803–01).

* * * * *

■ 3. Revise § 523.3 to read as follows:

§ 523.3 Automobile.

An automobile is any 4-wheeled vehicle that is propelled by fuel, or by alternative fuel, manufactured primarily for use on public streets, roads, and highways and rated at less than 10,000 pounds gross vehicle weight, except:

(a) A vehicle operated only on a rail line;

(b) A vehicle manufactured in different stages by 2 or more manufacturers, if no intermediate or final-stage manufacturer of that vehicle manufactures more than 10,000 multi-stage vehicles per year; or

(c) A work truck.

■ 4. Revise § 523.4 to read as follows:

§ 523.4 Passenger automobile.

A passenger automobile is any automobile (other than an automobile capable of off-highway operation) manufactured primarily for use in the transportation of not more than 10 individuals. A medium-duty passenger vehicle that does not meet the criteria for non-passenger motor vehicles in § 523.6 is a passenger automobile.

■ 5. Revise the introductory text of § 523.5 to read as follows:

§ 523.5 Non-passenger automobile.

A non-passenger automobile means an automobile that is not a passenger automobile or a work truck and includes vehicles described in paragraphs (a) and (b) of this section. A medium-duty passenger motor vehicle that meets the criteria in either paragraph (a) or (b) of this section is a non-passenger automobile.

* * * * *

■ 6. Revise § 523.6(a) to read as follows:

§ 523.6 Heavy-duty vehicle.

(a) A heavy-duty vehicle is any commercial medium- or heavy-duty on-highway vehicle or a work truck, as defined in 49 U.S.C. 32901(a)(7) and (19). For the purpose of this section, heavy-duty vehicles are divided into four regulatory categories as follows:

(1) Heavy-duty pickup trucks and vans;

(2) Heavy-duty vocational vehicles;

(3) Truck tractors with a GVWR above 26,000 pounds; and

(4) Heavy-duty trailers.

* * * * *

■ 7. Revise § 523.8(b) to read as follows:

§ 523.8 Heavy-duty vocational vehicle.

* * * * *

(b) Medium-duty passenger vehicles; and

* * * * *

PART 531—PASSENGER AUTOMOBILE AVERAGE FUEL ECONOMY STANDARDS

■ 8. The authority citation for part 531 continues to read as follows:

Authority: 49 U.S.C. 32902; delegation of authority at 49 CFR 1.95.

■ 9. Revise § 531.1 to read as follows:

§ 531.1 Scope.

This part establishes average fuel economy standards pursuant to 49 U.S.C. 32902 for passenger automobiles.

■ 10. Revise § 531.4 to read as follows:

§ 531.4 Definitions.

(a) *Statutory terms.* (1) The terms *average fuel economy, manufacture, manufacturer,* and *model year* are used as defined in 49 U.S.C. 32901.

(2) The terms *automobile* and *passenger automobile* are used as defined in 49 U.S.C. 32901 and in accordance with the determination in part 523 of this chapter.

(b) *Other terms.* As used in this part, unless otherwise required by the context—

(1) The term *domestically manufactured passenger automobile* means the vehicle is deemed to be manufactured domestically under 49 U.S.C. 32904(b)(3) and 40 CFR 600.511–08.

(2) [Reserved]

■ 11. Amend § 531.5 by revising paragraphs (a) through (d) to read as follows:

§ 531.5 Fuel economy standards.

(a) Except as provided in paragraph (e) of this section, each manufacturer of passenger automobiles shall comply with the fleet average fuel economy standards in table 1 to this paragraph (a), expressed in miles per gallon, in the model year specified as applicable:

TABLE 1 TO Paragraph (a)

Model year	Average fuel economy standard (miles per gallon)
1978	18.0
1979	19.0
1980	20.0
1981	22.0
1982	24.0
1983	26.0
1984	27.0
1985	27.5
1986	26.0
1987	26.0
1988	26.0
1989	26.5
1990–2010	27.5

(b) Except as provided in paragraph (e) of this section, for model year 2011, a manufacturer's passenger automobile fleet shall comply with the fleet average fuel economy level calculated for that model year according to figure 1 and the appropriate values in table 2 to this paragraph (b).

Figure 1 to Paragraph (b)

$$Required\_Fuel\_Economy\_Level = \frac{N}{\sum_i \frac{N_i}{T_i}}$$

Where:

N is the total number (sum) of passenger automobiles produced by a manufacturer;

N_i is the number (sum) of the *ith* passenger automobile model produced by the manufacturer; and

T_i is the fuel economy target of the *ith* model passenger automobile, which is determined according to the following formula, rounded to the nearest hundredth:

$$\frac{1}{\frac{1}{a} + \left(\frac{1}{b} - \frac{1}{a}\right)\frac{e^{(x-c)d}}{1 + e^{(x-c)d}}}$$

Where:

Parameters *a, b, c,* and *d* are defined in table 2 to this paragraph (b);

e = 2.718; and

x = footprint (in square feet, rounded to the nearest tenth) of the vehicle model.

TABLE 2 TO PARAGRAPH (B)— PARAMETERS FOR THE PASSENGER AUTOMOBILE FUEL ECONOMY TARGETS

Model year				Parameters
a (mpg)	b (mpg)	c (gal/mi/ft2)	d (gal/mi)	
2011	31.20	24.00	51.41	1.91

(c) Except as provided in paragraph (e) of this section, for model years 2012–2031, a manufacturer's passenger automobile fleet shall comply with the fleet average fuel economy level calculated for that model year according to this figure 2 and the appropriate values in this table 3 to this paragraph (c).

Figure 2 to Paragraph (c)

$$CAFE_{required} = \frac{\sum_i PRODUCTION_i}{\sum_i \frac{PRODUCTION_i}{TARGET_i}}$$

Where:

CAFE$_{required}$ is the fleet average fuel economy standard for a given fleet (domestic passenger automobiles or import passenger automobiles);

Subscript *i* is a designation of multiple groups of automobiles, where each group's designation, *i.e., i* = 1, 2, 3, etc., represents automobiles that share a unique model type and footprint within the applicable fleet, either domestic passenger automobiles or import passenger automobiles;

Production$_i$ is the number of passenger automobiles produced for sale in the United States within each *ith* designation, *i.e.,* which share the same model type and footprint;

TARGET$_i$ is the fuel economy target in miles per gallon (mpg) applicable to the footprint of passenger automobiles within each *ith* designation, *i.e.,* which share the same model type and footprint, calculated according to figure 3 to this paragraph (c) and rounded to the nearest hundredth of a mpg, *i.e.,* 35.455 = 35.46 mpg, and the summations in the numerator and denominator are both performed over all models in the fleet in question.

Figure 3 to Paragraph (c)

$$TARGET = \frac{1}{MIN\left[MAX\left(c \times FOOTPRINT + d, \frac{1}{a}\right), \frac{1}{b}\right]}$$

Where:

TARGET is the fuel economy target (in mpg) applicable to vehicles of a given footprint (*FOOTPRINT,* in square feet);

Parameters *a, b, c,* and *d* are defined in table 3 to this paragraph (c); and

The *MIN* and *MAX* functions take the minimum and maximum, respectively, of the included values.

TABLE 3 TO PARAGRAPH (c)—PARAMETERS FOR THE PASSENGER AUTOMOBILE FUEL ECONOMY TARGETS, MYS 2012–2031

Model year	Parameters			
	a (mpg)	b (mpg)	c (gal/mi/ft2)	d (gal/mi)
2012	35.95	27.95	0.0005308	0.006057
2013	36.80	28.46	0.0005308	0.005410
2014	37.75	29.03	0.0005308	0.004725
2015	39.24	29.90	0.0005308	0.003719
2016	41.09	30.96	0.0005308	0.002573
2017	43.61	32.65	0.0005131	0.001896
2018	45.21	33.84	0.0004954	0.001811
2019	46.87	35.07	0.0004783	0.001729
2020	48.74	36.47	0.0004603	0.001643
2021	49.48	37.02	0.000453	0.00162
2022	50.24	37.59	0.000447	0.00159
2023	51.00	38.16	0.000440	0.00157
2024	55.44	41.48	0.000405	0.00144
2025	60.26	45.08	0.000372	0.00133
2026	66.95	50.09	0.000335	0.00120
2027	68.32	51.12	0.00032841	0.00117220
2028	69.71	52.16	0.00032184	0.00114876
2029	71.14	53.22	0.00031541	0.00112579
2030	72.59	54.31	0.00030910	0.00110327
2031	74.07	55.42	0.00030292	0.00108120

(d) In addition to the requirements of paragraphs (b) and (c) of this section, each manufacturer, other than manufacturers subject to standards in paragraph (e) of this section, shall also meet the minimum fleet standard for domestically manufactured passenger automobiles expressed in table 4 to this paragraph (d):

TABLE 4 TO PARAGRAPH (d)—MINIMUM FUEL ECONOMY STANDARDS FOR DOMESTICALLY MANUFACTURED PASSENGER AUTOMOBILES, MYS 2011–2031

Model year	Minimum standard
2011	27.8
2012	30.7
2013	31.4
2014	32.1
2015	33.3
2016	34.7
2017	36.7
2018	38.0
2019	39.4
2020	40.9
2021	39.9
2022	40.6
2023	41.1
2024	44.3
2025	48.1
2026	53.5
2027	55.2
2028	56.3
2029	57.5
2030	58.6
2031	59.8

* * * * *

■ 9. Amend § 531.6 by revising paragraph (b) to read as follows:

§ 531.6 Measurement and calculation procedures.

* * * * *

(b) For model years 2017 through 2031, a manufacturer is eligible to increase the fuel economy performance of passenger cars in accordance with procedures established by the Environmental Protection Agency (EPA) set forth in 40 CFR part 600, subpart F, including adjustments to fuel economy for fuel consumption improvements related to air conditioning (AC) efficiency and off-cycle technologies. Starting in model year 2027, fuel economy increases for fuel consumption improvement values under 40 CFR 86.1868–12 and 40 CFR 86.1869–12 only apply for vehicles propelled by internal combustion engines. Manufacturers must provide reporting on these technologies as specified in § 537.7 of this chapter by the required deadlines.

(1) *Efficient AC technologies.* A manufacturer may increase its fleet average fuel economy performance through the use of technologies that improve the efficiency of AC systems pursuant to the requirements in 40 CFR 86.1868–12. Fuel consumption improvement values resulting from the use of those AC systems must be determined in accordance with 40 CFR 600.510–12(c)(3)(i).

(2) *Off-cycle technologies on EPA's predefined list.* A manufacturer may increase its fleet average fuel economy performance through the use of off-cycle technologies pursuant to the requirements in 40 CFR 86.1869–12 for predefined off-cycle technologies in accordance with 40 CFR 86.1869–12(b). The fuel consumption improvement is determined in accordance with 40 CFR 600.510–12(c)(3)(ii).

(3) *Off-cycle technologies using 5-cycle testing.* Through model year 2026, a manufacturer may increase its fleet average fuel economy performance through the use of off-cycle technologies tested using the EPA's 5-cycle methodology in accordance with 40 CFR 86.1869–12(c). The fuel consumption improvement is determined in accordance with 40 CFR 600.510–12(c)(3)(ii).

(4) *Off-cycle technologies using the alternative EPA-approved methodology.* Through model year 2026, a manufacturer may seek to increase its fuel economy performance through use of an off-cycle technology requiring an application request made to the EPA in accordance with 40 CFR 86.1869–12(d).

(i) *Eligibility under the Corporate Average Fuel Economy (CAFE) program requires compliance with paragraphs (b)(4)(i)(A) through (C) of this section.* Paragraphs (b)(4)(i)(A), (B) and (D) of this section apply starting in model year 2024. Paragraph (b)(4)(i)(E) of this section applies starting in model year 2025.

(A) A manufacturer seeking to increase its fuel economy performance using the alternative methodology for an off-cycle technology, should submit a detailed analytical plan to EPA prior to the applicable model year. The detailed analytical plan may include information, such as planned test procedure and model types for demonstration. The plan will be approved or denied in accordance with 40 CFR 86.1869.12(d).

(B) A manufacturer seeking to increase its CAFE program fuel economy performance using the alternative methodology for an off-cycle technology must submit an official credit application to EPA and obtain approval in accordance with 40 CFR 86.1869.12(e) prior to September of the given model year.

(C) A manufacturer's plans, applications and requests approved by the EPA must be made in consultation with NHTSA. To expedite NHTSA's consultation with the EPA, a manufacturer must concurrently submit its application to NHTSA if the manufacturer is seeking off-cycle fuel economy improvement values under the CAFE program for those technologies. For off-cycle technologies that are covered under 40 CFR 86.1869–12(d), NHTSA will consult with the EPA regarding NHTSA's evaluation of the specific off-cycle technology to ensure its impact on fuel economy and the suitability of using the off-cycle technology to adjust the fuel economy performance.

(D) A manufacturer may request an extension from NHTSA for more time to obtain an EPA approval. Manufacturers should submit their requests 30 days before the deadlines in paragraphs (b)(4)(i)(A) through (C) of this section. Requests should be submitted to NHTSA's Director of the Office of Vehicle Safety Compliance at *cafe@dot.gov.*

(E) For MYs 2025 and 2026, a manufacturer must respond within 60-days to any requests from EPA or NHTSA for additional information or clarifications to submissions provided pursuant to paragraphs (b)(4)(i)(A) and (B) of this section. Failure to respond within 60 days may result in denial of the manufacturer's request to increase its fuel economy performance through use of an off-cycle technology requests made to the EPA in accordance with 40 CFR 86.1869–12(d).

(ii) *Review and approval process.* NHTSA will provide its views on the suitability of the technology for that purpose to the EPA. NHTSA's evaluation and review will consider:

(A) Whether the technology has a direct impact upon improving fuel economy performance;

(B) Whether the technology is related to crash-avoidance technologies, safety critical systems or systems affecting safety-critical functions, or technologies designed for the purpose of reducing the frequency of vehicle crashes;

(C) Information from any assessments conducted by the EPA related to the application, the technology and/or related technologies; and

(D) Any other relevant factors.

(iii) *Safety.* (A) Technologies found to be defective or non-compliant, subject to recall pursuant to part 573 of this chapter, Defect and Noncompliance Responsibility and Reports, due to a risk to motor vehicle safety, will have the values of approved off-cycle credits removed from the manufacturer's credit balance or adjusted to the population of vehicles the manufacturer remedies as required by 49 U.S.C. chapter 301. NHTSA will consult with the manufacturer to determine the amount of the adjustment.

(B) Approval granted for innovative and off-cycle technology credits under NHTSA's fuel efficiency program does not affect or relieve the obligation to comply with the Vehicle Safety Act (49 U.S.C. chapter 301), including the ''make inoperative'' prohibition (49 U.S.C. 30122), and all applicable Federal motor vehicle safety standards (FMVSSs) issued thereunder (part 571 of this chapter). In order to generate off-cycle or innovative technology credits manufacturers must state—

(*1*) That each vehicle equipped with the technology for which they are seeking credits will comply with all applicable FMVSS(s); and

(*2*) Whether or not the technology has a fail-safe provision. If no fail-safe provision exists, the manufacturer must explain why not and whether a failure of the innovative technology would affect the safety of the vehicle.

PART 533—LIGHT TRUCK FUEL ECONOMY STANDARDS

■ 10. The authority citation for part 533 continues to read as follows:

Authority: 49 U.S.C. 32902; delegation of authority at 49 CFR 1.95.

■ 11. Revise § 533.1 to read as follows:

§ 533.1 Scope.

This part establishes average fuel economy standards pursuant to 49 U.S.C. 32902 for light trucks.

■ 12. Revise § 533.4 to read as follows:

§ 533.4 Definitions.

(a) *Statutory terms.* (1) The terms *average fuel economy, average fuel economy standard, fuel economy, import, manufacture, manufacturer,* and *model year* are used as defined in 49 U.S.C. 32901.

(2) The term *automobile* is used as defined in 49 U.S.C. 32901 and in accordance with the determinations in part 523 of this chapter.

(b) *Other terms.* As used in this part, unless otherwise required by the context—

(1) *Light truck* is used in accordance with the determinations in part 523 of this chapter.

(2) *Captive import* means with respect to a light truck, one which is not domestically manufactured, as defined in section 502(b)(2)(E) of the Motor Vehicle Information and Cost Savings Act, but which is imported in the 1980 model year or thereafter by a manufacturer whose principal place of business is in the United States.

(3) *4-wheel drive, general utility vehicle* means a 4-wheel drive, general purpose automobile capable of off-highway operation that has a wheelbase of not more than 280 centimeters, and that has a body shape similar to 1977 Jeep CJ–5 or CJ–7, or the 1977 Toyota Land Cruiser.

(4) *Basic engine* means a unique combination of manufacturer, engine displacement, number of cylinders, fuel system (as distinguished by number of carburetor barrels or use of fuel injection), and catalyst usage.

(5) *Limited product line light truck* means a light truck manufactured by a manufacturer whose light truck fleet is powered exclusively by basic engines which are not also used in passenger automobiles.

■ 13. Amend § 533.5 by revising table 7 to paragraph (a) and paragraph (j) to read as follows:

§ 533.5 Requirements.

(a) * * *

TABLE 7 TO PARAGRAPH (a)–PARAMETERS FOR THE LIGHT TRUCK FUEL ECONOMY TARGETS FOR MYS, 2017–2031

Model year	Parameters							
	a (mpg)	b (mpg)	c (gal/mi/ft2)	d (gal/mi)	e (mpg)	f (mpg)	g (gal/mi/ft2)	h (gal/mi)
2017	36.26	25.09	0.0005484	0.005097	35.10	25.09	0.0004546	0.009851
2018	37.36	25.20	0.0005358	0.004797	35.31	25.20	0.0004546	0.009682
2019	38.16	25.25	0.0005265	0.004623	35.41	25.25	0.0004546	0.009603
2020	39.11	25.25	0.0005140	0.004494	35.41	25.25	0.0004546	0.009603
2021	39.71	25.63	0.000506	0.00443	NA	NA	NA	NA
2022	40.31	26.02	0.000499	0.00436	NA	NA	NA	NA
2023	40.93	26.42	0.000491	0.00429	NA	NA	NA	NA
2024	44.48	26.74	0.000452	0.00395	NA	NA	NA	NA
2025	48.35	29.07	0.000416	0.00364	NA	NA	NA	NA
2026	53.73	32.30	0.000374	0.00327	NA	NA	NA	NA
2027	53.73	32.30	0.00037418	0.00327158	NA	NA	NA	NA
2028	53.73	32.30	0.00037418	0.00327158	NA	NA	NA	NA
2029	54.82	32.96	0.00036670	0.00320615	NA	NA	NA	NA
2030	55.94	33.63	0.00035936	0.00314202	NA	NA	NA	NA
2031	57.08	34.32	0.00035218	0.00307918	NA	NA	NA	NA

* * * * *

(j) For model years 2017–2031, a manufacturer's light truck fleet shall comply with the fleet average fuel economy standard calculated for that model year according to figures 2 and 4 to paragraph (a) of this section and the appropriate values in table 7 to paragraph (a) of this section.

■ 14. Amend § 533.6 by:

■ a. Revising paragraph (c) to read as follows:

§ 533.6 Measurement and calculation procedures.

* * * * *

(c) For model years 2017 through 2031, a manufacturer is eligible to increase the fuel economy performance of light trucks in accordance with procedures established by the Environmental Protection Agency (EPA) set forth in 40 CFR part 600, subpart F, including adjustments to fuel economy for fuel consumption improvements related to air conditioning (AC) efficiency, off-cycle technologies, and hybridization and other performance-based technologies for full-size pickup trucks that meet the requirements specified in 40 CFR 86.1803. Starting in model year 2027, fuel economy increases for fuel consumption improvement values under 40 CFR 86.1868–12 and 40 CFR 86.1869–12 only apply for vehicles propelled by internal combustion engines.

Manufacturers must provide reporting on these technologies as specified in § 537.7 of this chapter by the required deadlines.

(1) *Efficient AC technologies.* A manufacturer may seek to increase its fleet average fuel economy performance through the use of technologies that improve the efficiency of AC systems pursuant to the requirements in 40 CFR 86.1868–12. Fuel consumption improvement values resulting from the use of those AC systems must be determined in accordance with 40 CFR 600.510–12(c)(3)(i).

(2) *Incentives for advanced full-size light-duty pickup trucks.* For model year 2023 and 2024, the eligibility of a manufacturer to increase its fuel economy using hybridized and other performance-based technologies for full-size pickup trucks must follow 40 CFR 86.1870–12 and the fuel consumption improvement of these full-size pickup truck technologies must be determined in accordance with 40 CFR 600.510–12(c)(3)(iii). Manufacturers may also combine incentives for full size pickups and dedicated alternative fueled vehicles when calculating fuel economy performance values in 40 CFR 600.510–12.

(3) *Off-cycle technologies on EPA's predefined list.* A manufacturer may seek to increase its fleet average fuel economy performance through the use of off-cycle technologies pursuant to the requirements in 40 CFR 86.1869–12 for predefined off-cycle technologies in accordance with 40 CFR 86.1869–12(b). The fuel consumption improvement is determined in accordance with 40 CFR 600.510–12(c)(3)(ii).

(4) *Off-cycle technologies using 5-cycle testing.* Through model year 2026, a manufacturer may only increase its fleet average fuel economy performance through the use of off-cycle technologies tested using the EPA's 5-cycle methodology in accordance with 40 CFR 86.1869–12(c). The fuel consumption improvement is determined in accordance with 40 CFR 600.510–12(c)(3)(ii).

(5) *Off-cycle technologies using the alternative EPA-approved methodology.* Through model year 2026, a manufacturer may seek to increase its fuel economy performance through the use of an off-cycle technology requiring an application request made to the EPA in accordance with 40 CFR 86.1869–12(d).

(i) *Eligibility under the Corporate Average Fuel Economy (CAFE) program requires compliance with paragraphs (c)(5)(i)(A) through (C) of this section.* Paragraphs (c)(5)(i)(A), (B) and (D) of this section apply starting in model year 2024. Paragraph (b)(5)(i)(E) of this section applies starting in model year 2025.

(A) A manufacturer seeking to increase its fuel economy performance using the alternative methodology for an off-cycle technology, should submit a detailed analytical plan to EPA prior to the applicable model year. The detailed analytical plan may include information such as, planned test procedure and model types for demonstration. The plan will be approved or denied in accordance with 40 CFR 86.1869–12(d).

(B) A manufacturer seeking to increase its fuel economy performance using the alternative methodology for an off-cycle technology must submit an official credit application to EPA and obtain approval in accordance with 40 CFR 86.1869–12(e) prior to September of the given model year.

(C) A manufacturer's plans, applications and requests approved by the EPA must be made in consultation with NHTSA. To expedite NHTSA's consultation with the EPA, a manufacturer must concurrently submit its application to NHTSA if the manufacturer is seeking off-cycle fuel economy improvement values under the CAFE program for those technologies. For off-cycle technologies that are covered under 40 CFR 86.1869–12(d), NHTSA will consult with the EPA regarding NHTSA's evaluation of the specific off-cycle technology to ensure its impact on fuel economy and the suitability of using the off-cycle technology to adjust the fuel economy performance.

(D) A manufacturer may request an extension from NHTSA for more time to obtain an EPA approval. Manufacturers should submit their requests 30 days before the deadlines above. Requests should be submitted to NHTSA's Director of the Office of Vehicle Safety Compliance at *cafe@dot.gov.*

(E) For MYs 2025 and 2026, a manufacturer must respond within 60-days to any requests from EPA or NHTSA for additional information or clarifications to submissions provided pursuant to paragraphs (b)(4)(i)(A) and (B) of this section. Failure to respond within 60 days may result in denial of the manufacturer's request to increase its fuel economy performance through use of an off-cycle technology requests made to the EPA in accordance with 40 CFR 86.1869–12(d).

(ii) *Review and approval process.* NHTSA will provide its views on the suitability of the technology for that purpose to the EPA. NHTSA's evaluation and review will consider:

(A) Whether the technology has a direct impact upon improving fuel economy performance;

(B) Whether the technology is related to crash-avoidance technologies, safety critical systems or systems affecting safety-critical functions, or technologies designed for the purpose of reducing the frequency of vehicle crashes;

(C) Information from any assessments conducted by the EPA related to the application, the technology and/or related technologies; and

(D) Any other relevant factors.

(E) NHTSA will collaborate to host annual meetings with EPA at least once by July 30th before the model year begins to provide general guidance to the industry on past off-cycle approvals.

(iii) *Safety.* (A) Technologies found to be defective or non-compliant, subject to recall pursuant to part 573 of this chapter, Defect and Noncompliance Responsibility and Reports, due to a risk to motor vehicle safety, will have the values of approved off-cycle credits removed from the manufacturer's credit balance or adjusted to the population of vehicles the manufacturer remedies as required by 49 U.S.C. chapter 301. NHTSA will consult with the manufacturer to determine the amount of the adjustment.

(B) Approval granted for innovative and off-cycle technology credits under NHTSA's fuel efficiency program does not affect or relieve the obligation to comply with the Vehicle Safety Act (49 U.S.C. chapter 301), including the ''make inoperative'' prohibition (49 U.S.C. 30122), and all applicable Federal motor vehicle safety standards issued thereunder (FMVSSs) (part 571 of this chapter). In order to generate off-cycle or innovative technology credits manufacturers must state—

(*1*) That each vehicle equipped with the technology for which they are seeking credits will comply with all applicable FMVSS(s); and

(*2*) Whether or not the technology has a fail-safe provision. If no fail-safe provision exists, the manufacturer must explain why not and whether a failure of the innovative technology would affect the safety of the vehicle.

PART 535 MEDIUM- AND HEAVY-DUTY VEHICLE FUEL EFFICIENCY PROGRAM

■ 15. The authority citation for part 535 continues to read as follows:

Authority: 49 U.S.C. 32902 and 30101; delegation of authority at 49 CFR 1.95.

■ 16. Amend § 535.4 by revising the introductory text, removing the definition for ''Alterers'', and adding the definition for ''Alterer'', in alphabetical order, to read as follows:

§ 535.4 Definitions.

The terms manufacture, manufacturer, commercial medium-duty on highway vehicle, commercial heavy-duty on highway vehicle, fuel, and work truck are used as defined in 49 U.S.C. 32901. See 49 CFR 523.2 for general definitions related to NHTSA's fuel efficiency programs.

* * * * *

Alterer means a manufacturer that modifies an altered vehicle as defined in 49 CFR 567.3

* * * * *

■ 17. Amend § 535.5 by revising paragraphs (a)(1), (2) and (9) to read as follows:

§ 535.5 Standards.

(a) * * *

(1) *Mandatory standards.* For model years 2016 and later, each manufacturer must comply with the fleet average standard derived from the unique subconfiguration target standards (or groups of subconfigurations approved by EPA in accordance with 40 CFR 86.1819) of the model types that make up the manufacturer's fleet in a given model year. Each subconfiguration has a unique attribute-based target standard, defined by each group of vehicles having the same payload, towing capacity and whether the vehicles are equipped with a 2-wheel or 4-wheel drive configuration. Phase 1 target standards apply for model years 2016 through 2020. Phase 2 target standards apply for model years 2021 through 2029. NHTSA's Phase 3 HDPUV target standards apply for model year 2030 and later.

(2) *Subconfiguration target standards.* (i) Two alternatives exist for determining the subconfiguration target standards for Phase 1. For each alternative, separate standards exist for compression-ignition and spark-ignition vehicles:

(A) The first alternative allows manufacturers to determine a fixed fuel consumption standard that is constant over the model years; and

(B) The second alternative allows manufacturers to determine standards that are phased-in gradually each year.

(ii) Calculate the subconfiguration target standards as specified in this paragraph (a)(2)(ii), using the appropriate coefficients from table 1 to paragraph (a)(2)(ii), choosing between the alternatives in paragraph (a)(2)(i) of this section. For electric or fuel cell heavy-duty vehicles, use compression-ignition vehicle coefficients ''c'' and ''d'' and for hybrid (including plug-in hybrid), dedicated and dual-fueled vehicles, use coefficients ''c'' and ''d'' appropriate for the engine type used. Round each standard to the nearest 0.001 gallons per 100 miles and specify all weights in pounds rounded to the nearest pound. Calculate the subconfiguration target standards using equation: 1 to this paragraph (a)(2)(ii).

Equation 1 to Paragraph (a)(2)(ii)

$$\text{Subconfiguration Target Standard (gallons per 100 miles)} = [c \times (WF)] + d$$

Where:

WF = Work Factor = [0.75 × (Payload Capacity + Xwd)] + [0.25 × Towing Capacity]

Xwd = 4wd Adjustment = 500 lbs. if the vehicle group is equipped with 4wd and all-wheel drive, otherwise equals 0 lbs. for 2wd.

Payload Capacity = GVWR (lbs.) − Curb Weight (lbs.) (for each vehicle group)

Towing Capacity = GCWR (lbs.) − GVWR (lbs.) (for each vehicle group)

TABLE 1 TO PARAGRAPH (a)(2)(ii)—COEFFICIENTS FOR MANDATORY SUBCONFIGURATION TARGET STANDARDS

Model year(s)	c	d
Phase 1 Alternative 1—Fixed Target Standards **Compression Ignition (CI) Vehicle Coefficients**		
2016 to 2018	0.0004322	3.330
2019 to 2020	0.0004086	3.143
SI Vehicle Coefficients		
2016 to 2017	0.0005131	3.961
2018 to 2020	0.0004086	3.143
Phase 1 Alternative 2—Phased-in Target Standards		
CI Vehicle Coefficients		
2016	0.0004519	3.477
2017	0.0004371	3.369
2018 to 2020	0.0004086	3.143
SI Vehicle Coefficients		
2016	0.0005277	4.073
2017	0.0005176	3.983
2018 to 2020	0.0004951	3.815
Phase 2—Fixed Target Standards		
CI Vehicle Coefficients		
2021	0.0003988	3.065
2022	0.0003880	2.986
2023	0.0003792	2.917
2024	0.0003694	2.839
2025	0.0003605	2.770
2026	0.0003507	2.701
2027 to 2029	0.0003418	2.633

TABLE 1 TO PARAGRAPH (a)(2)(ii)—COEFFICIENTS FOR MANDATORY SUBCONFIGURATION TARGET STANDARDS—Continued

Model year(s)	c	d
2030	0.00030762	2.370
2031	0.00027686	2.133
2032	0.00024917	1.919
2033	0.00022924	1.766
2034	0.00021090	1.625
2035	0.00019403	1.495
SI Vehicle Coefficients		
2021	0.0004827	3.725
2022	0.0004703	3.623
2023	0.0004591	3.533
2024	0.0004478	3.443
2025	0.0004366	3.364
2026	0.0004253	3.274
2027 to 2029	0.0004152	3.196
2030	0.00037368	2.876
2031	0.00033631	2.589
2032	0.00030268	2.330
2033	0.00027847	2.143
2034	0.00025619	1.972
2035	0.00023569	1.814

* * * * *

(9) *Advanced, innovative, and off-cycle technologies.* For vehicles subject to Phase 1 standards, manufacturers may generate separate credit allowances for advanced and innovative technologies as specified in § 535.7(f)(1) and (2). For vehicles subject to Phase 2 standards, manufacturers may generate separate credits allowance for off-cycle technologies in accordance with § 535.7(f)(2) through model year 2029. Separate credit allowances for advanced technology vehicles cannot be generated; instead, manufacturers may use the credit specified in § 535.7(f)(1)(ii) through model year 2027.

* * * * *

■ 18. Amend § 535.6 by revising paragraph (a)(1) to read as follows:

§ 535.6 easurement and calculation procedures.

* * * * *

(a) * * *

(1) For the Phase 1 program, if the manufacturer's fleet includes conventional vehicles (gasoline, diesel and alternative fueled vehicles) and advanced technology vehicles (hybrids with powertrain designs that include energy storage systems, vehicles with waste heat recovery, electric vehicles and fuel cell vehicles), it may divide its fleet into two separate fleets each with its own separate fleet average fuel consumption performance rate. For Phase 2 and later, manufacturers may calculate their fleet average fuel consumption rates for a conventional fleet and separate advanced technology vehicle fleets. Advanced technology vehicle fleets should be separated into plug-in hybrid electric vehicles, electric vehicles and fuel cell vehicles.

* * * * *

■ 19. Amend § 535.7 by revising paragraphs (a)(1)(iii) and (iv), (a)(2)(iii), (a)(4)(i) and (ii), (b)(2), (f)(2) introductory text, (f)(2)(ii), and (f)(2)(vi)(B) to read as follows:

§ 535.7 Averaging, banking, and trading (ABT) credit program.

(a) * * *

(1) * * *

(iii) *Advanced technology credits.* Credits generated by vehicle or engine families or subconfigurations containing vehicles with advanced technologies (*i.e.,* hybrids with regenerative braking, vehicles equipped with Rankine-cycle engines, electric and fuel cell vehicles) as described in paragraph (f)(1) of this section.

(iv) *Innovative and off-cycle technology credits.* Credits can be generated by vehicle or engine families or subconfigurations having fuel consumption reductions resulting from technologies not reflected in the GEM simulation tool or in the Federal Test Procedure (FTP) chassis dynamometer and that were not in common use with heavy-duty vehicles or engines before model year 2010 that are not reflected in the specified test procedure. Manufacturers should prove that these technologies were not in common use in heavy-duty vehicles or engines before model year 2010 by demonstrating factors such as the penetration rates of the technology in the market. NHTSA will not approve any request if it determines that these technologies do not qualify. The approach for determining innovative and off-cycle technology credits under this fuel consumption program is described in paragraph (f)(2) of this section and by the Environmental Protection Agency (EPA) under 40 CFR 86.1819–14(d)(13), 1036.610, and 1037.610. Starting in model year 2030, manufacturers certifying vehicles under § 535.5(a) may not earn off-cycle technology credits under 40 CFR 86.1819–14(d)(13).

(2) * * *

(iii) Positive credits, other than advanced technology credits in Phase 1, generated and calculated within an averaging set may only be used to offset negative credits within the same averaging set.

* * * * *

(4) * * *

(i) Manufacturers may only trade banked credits to other manufacturers to use for compliance with fuel consumption standards. Traded FCCs, other than advanced technology credits earned in Phase 1, may be used only within the averaging set in which they were generated. Manufacturers may only trade credits to other entities for the purpose of expiring credits.

(ii) Advanced technology credits earned in Phase 1 can be traded across different averaging sets.

* * * * *

(b) * * *

(2) Adjust the fuel consumption performance of subconfigurations with advanced technology for determining the fleet average actual fuel consumption value as specified in paragraph (f)(1) of this section and 40 CFR 86.1819–14(d)(6)(iii). Advanced technology vehicles can be separated in a different fleet for the purpose of applying credit incentives as described in paragraph (f)(1) of this section.

* * * * *

(f) * * *

(2) *Innovative and off-cycle technology credits.* This provision allows fuel saving innovative and off-cycle engine and vehicle technologies to generate fuel consumption credits (FCCs) comparable to CO² emission credits consistent with the provisions of 40 CFR 86.1819–14(d)(13) (for heavy-duty pickup trucks and vans), 40 CFR 1036.610 (for engines), and 40 CFR 1037.610 (for vocational vehicles and tractors). Heavy-duty pickup trucks and vans may only generate FCCs through model year 2029.

* * * * *

(ii) For model years 2021 and later, or for model years 2021 through 2029, for heavy-duty pickup trucks and vans manufacturers may generate off-cycle technology credits for introducing technologies that are not reflected in the EPA specified test procedures. Upon identification and joint approval with EPA, NHTSA will allow equivalent FCCs into its program to those allowed by EPA for manufacturers seeking to obtain innovative technology credits in a given model year. Such credits must remain within the same regulatory subcategory in which the credits were generated. NHTSA will adopt FCCs depending upon whether—

(A) The technology meets paragraphs (f)(2)(i)(A) and (B) of this section.

(B) For heavy-duty pickup trucks and vans, manufacturers using the 5-cycle test to quantify the benefit of a technology are not required to obtain approval from the agencies to generate results.

* * * * *

(vi) * * *

(B) For model years 2021 and later, or for model years 2021 through 2029 for heavy-duty pickup trucks and vans, manufacturers may not rely on an approval for model years before 2021. Manufacturers must separately request the agencies' approval before applying an improvement factor or credit under this section for 2021 and later engines and vehicle, even if the agencies approve the improvement factor or credit for similar engine and vehicle models before model year 2021.

* * * * *

PART 536—TRANSFER AND TRADING OF FUEL ECONOMY CREDITS

■ 20. The authority citation for part 536 continues to read as follows:

Authority: 49 U.S.C. 32903; delegation of authority at 49 CFR 1.95.

■ 21. Revise Table 1 to § 536.4(c) to read as follows:

§ 536.4 Credits.

* * * * *

TABLE 1 TO § 536.4(c)—LIFETIME VEHICLE MILES TRAVELED

Model year	Lifetime vehicle miles traveled (VMT)					
	2012	2013	2014	2015	2016	2017–2031
Passenger Cars	177,238	177,366	178,652	180,497	182,134	195,264
Light Trucks	208,471	208,537	209,974	212,040	213,954	225,865

PART 537—AUTOMOTIVE FUEL ECONOMY REPORTS

■ 22. The authority citation for part 537 continues to read as follows:

Authority: 49 U.S.C. 32907; delegation of authority at 49 CFR 1.95.

■ 23. Revise § 537.2 to read as follows:

§ 537.2 Purpose.

The purpose of this part is to obtain information to aid the National Highway Traffic Safety Administration in evaluating automobile manufacturers' plans for complying with average fuel economy standards and in preparing an annual review of the average fuel economy standards.

■ 24. Revise § 537.3 to read as follows:

§ 537.3 Applicability.

This part applies to automobile manufacturers, except for manufacturers subject to an alternate fuel economy standard under 49 U.S.C. 32902(d).

■ 25. Revise § 537.4 to read as follows:

§ 537.4 Definitions.

(a) *Statutory terms.* (1) The terms *average fuel economy standard, fuel, manufacture,* and *model year* are used as defined in 49 U.S.C. 32901.

(2) The term *manufacturer* is used as defined in 49 U.S.C. 32901 and in accordance with part 529 of this chapter.

(3) The terms *average fuel economy, fuel economy,* and *model type* are used as defined in subpart A of 40 CFR part 600.

(4) The terms *automobile, automobile capable of off-highway operation,* and *passenger automobile* are used as defined in 49 U.S.C. 32901 and in accordance with the determinations in part 523 of this chapter.

(b) *Other terms.* (1) The term *loaded vehicle weight* is used as defined in subpart A of 40 CFR part 86.

(2) The terms *axle ratio, base level, body style, car line, combined fuel economy, engine code, equivalent test weight, gross vehicle weight, inertia weight, transmission class,* and *vehicle configuration* are used as defined in subpart A of 40 CFR part 600.

(3) The term *light truck* is used as defined in part 523 of this chapter and in accordance with determinations in that part.

(4) The terms *approach angle, axle clearance, brakeover angle, cargo carrying volume, departure angle, passenger carrying volume, running clearance,* and *temporary living quarters* are used as defined in part 523 of this chapter.

(5) The term *incomplete automobile manufacturer* is used as defined in part 529 of this chapter.

(6) As used in this part, unless otherwise required by the context:

(i) *Administrator* means the Administrator of the National Highway Traffic Safety Administration or the Administrator's delegate.

(ii) *Current model year* means:

(A) In the case of a pre-model year report, the full model year immediately following the period during which that report is required by § 537.5(b) to be submitted.

(B) In the case of a mid-model year report, the model year during which that report is required by § 537.5(b) to be submitted.

(iii) *Average* means a production-weighted harmonic average.

(iv) *Total drive ratio* means the ratio of an automobile's engine rotational speed (in revolutions per minute) to the automobile's forward speed (in miles per hour).

■ 26. Amend § 537.7 by revising paragraphs (c)(7)(i) through (iii) to read as follows:

§ 537.7 Pre-model year and mid-model year reports.

* * * * *

(c) * * *

(7) * * *

(i) Provide a list of each air conditioning (AC) efficiency improvement technology utilized in your fleet(s) of vehicles for each model year for which the manufacturer qualifies for fuel consumption improvement values under 49 CFR 531.6 or 533.6. For each technology identify vehicles by make and model types that have the technology, which compliance category those vehicles belong to and the number of vehicles for each model equipped with the technology. For each compliance category (domestic passenger car, import passenger car, and light truck), report the AC fuel consumption improvement value in gallons/mile in accordance with the equation specified in 40 CFI00.510–12(c)(3)(i).

(ii) Manufacturers must provide a list of off-cycle efficiency improvement technologies utilized in its fleet(s) of vehicles for each model year that is pending or approved by the Environmental Protection Agency (EPA) for which the manufacturer qualifies for fuel consumption improvement values under 49 CFR 531.6 or 533.6. For each technology, manufacturers must identify vehicles by make and model types that have the technology, which compliance category those vehicles belong to, the number of vehicles for each model equipped with the technology, and the associated off-cycle credits (grams/mile) available for each technology. For each compliance category (domestic passenger car, import passenger car, and light truck), manufacturers must calculate the fleet off-cycle fuel consumption improvement value in gallons/mile in accordance with the equation specified in 40 CFR 600.510–12(c)(3)(ii).

(iii) For model years up to 2024, manufacturers must provide a list of full-size pickup trucks in its fleet that meet the mild and strong hybrid vehicle definitions. For each mild and strong hybrid type, manufacturers must identify vehicles by make and model types that have the technology, the number of vehicles produced for each model equipped with the technology, the total number of full-size pickup trucks produced with and without the technology, the calculated percentage of hybrid vehicles relative to the total number of vehicles produced, and the associated full-size pickup truck credits (grams/mile) available for each technology. For the light truck compliance category, manufacturers must calculate the fleet pickup truck fuel consumption improvement value in gallons/mile in accordance with the equation specified in 40 CFR 600.510–12(c)(3)(iii).

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Sophie Shulman,

Deputy Administrator.

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