Preliminary Regulatory Impact Analysis

The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule III for Model Years 2022 to 2031 Passenger Cars and Light Trucks

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NHTSA

Table of Contents

Tables

Figures

Equations

Table of Acronyms and Abbreviations

Abbreviation	Term
AC	Air Conditioning
ADAS	Advanced Driver Assistance Systems
AEB	Automatic Emergency Braking
AEO	Annual Energy Outlook
AERO	Aerodynamic Drag Technology
AERO0	Base Level Aerodynamic Drag Technology
AERO5	Aerodynamic Drag, 5% Drag Coefficient Reduction
AERO10	Aerodynamic Drag, 10% Drag Coefficient Reduction
AERO20	Aerodynamic Drag, 20% Drag Coefficient Reduction
AMPC	Advanced Manufacturing Production Credit
Argonne	Argonne National Laboratory
AT	Automatic transmissions
AT8	8-Speed Automatic Transmission
AT8L2	8-Speed Automatic Transmission with Level 2 HEG
AT10L3	10-Speed Automatic Transmission with Level 3 HEG
AWD	All-Wheel Drive
BISG	Belt-Integrated Starter Generator
BTW	Brake and Tire Wear
CAFE	Corporate Average Fuel Economy
CH_4	Methane
CNG	Compressed Natural Gas
CO_2	Carbon Dioxide
CVT	Continuously Variable Transmission
CY	Calendar Year
DOE	U.S. Department of Energy
DOHC	Dual Overhead Camshaft
DOT	U.S. Department of Transportation
E.O.	Executive Order
EIA	U.S. Energy Information Administration
EIS	Environmental Impact Statement
EISA	Energy Independence and Security Act of 2007
EPA	U. S. Environmental Protection Agency
EPCA	Energy Policy and Conservation Act of 1975
FCIV	Fuel Consumption Improvement Value
GM	General Motors
gpm	gallons per mile

GDP	Gross Domestic Product
GREET	Greenhouse gases, Regulated Emissions, and Energy use in Transportation
GVWR	Gross Vehicle Weight Rating
HCR	High Compression Ratio
HTF	Highway Trust Fund
ICE	Internal Combustion Engine
LD	Light Duty
LT	Light Truck
MDPCS	Minimum Domestic Passenger Car Standard
mmT	million metric tons
MOVES	Motor Vehicle Emission Simulator
MPG	Miles Per Gallon
mph	miles per hour
MR	Mass Reduction
MR0	Base Level Mass Reduction Technology
MR1	Mass Reduction – 5.0% of Glider
MR3	Mass Reduction – 10.0% of Glider
MR4	Mass Reduction – 15.0% of Glider
MSRP	Manufacturer Suggested Retail Price
MY	Model Year
NCE	Non-Criteria Emission
NHTSA	National Highway Traffic Safety Administration
PDO	Property Damage-Only
N_2O	Nitrous Oxide
NO_X	Nitrogen Oxides
OC	Off-Cycle
OIRA	Office of Information and Regulatory Affairs
OMB	Office of Management and Budget
PC	Passenger Car
PHEV	Plug-in Hybrid Electric Vehicle
PM	Particulate Matter
$PM_{2.5}$	Particulate matter 2.5 microns or less in diameter
PRIA	Preliminary Regulatory Impact Analysis
ROLL	Tire Rolling Resistance
ROLL0	Base Level Tire Rolling Resistance
ROLL30	Tire Rolling Resistance, 30% Improvement
SAFE	Safer Affordable Fuel-Efficient
SGDI	Stoichiometric Gasoline Direct Injection
SHEV	Strong Hybrid Electric Vehicle
SHEVP	Power-Split Strong Hybrid Electric Vehicle

SO_X	Sulfur Oxides
SS12V	12V Micro Hybrid Start-Stop System
SUV	Sport Utility Vehicle
TSD	Technical Support Document
TURBO0	reference baseline turbocharged downsized technology
TURBO2	advanced turbocharged downsized technology
U.S.	United States
U.S.C.	United States Code
VMT	Vehicle Miles Traveled
Volpe or Volpe Center	Volpe National Transportation Systems Center

1. Executive Summary

Pursuant to Executive Order (E.O.) 12866 and E.O. 13563, the National Highway Traffic Safety Administration (NHTSA) has prepared this Preliminary Regulatory Impact Analysis (PRIA) to assess the potential and anticipated consequences of proposed Corporate Average Fuel Economy (CAFE) standards. Regulatory impact analysis is a tool used to anticipate and evaluate the likely consequences of rules by providing a formal way of organizing and presenting the key effects, positive and negative, of the various alternatives that are considered in developing regulations. The goal of this PRIA is to consolidate evidence and to inform decision-makers of the potential consequences of the regulatory paths being considered.

This proposed rule is issued under the agency's authority granted by the Energy Policy and Conservation Act of 1975 (EPCA)[1] as amended by the Energy Independence and Security Act of 2007 (EISA)[2] and other legislation.[3] EPCA, as amended by EISA, contains a number of provisions governing how NHTSA must set CAFE standards.[4] CAFE standards must be set separately for passenger cars (PCs) and light trucks (LTs),[5] and they must be set using a vehicle attribute related to fuel economy and based on a mathematical function. The mathematical function or "curve" representing the standards is a constrained linear function that provides a separate fuel economy target for each vehicle footprint (track width times wheelbase). Vehicle footprint has been used as the relevant attribute for passenger car and light truck curves since model year (MY) 2011. Each manufacturer is subject to individualized compliance obligations for passenger cars and light trucks in each model year, based on the footprints and sales volumes of the vehicles it produces.

NHTSA must set CAFE standards at the "maximum feasible average fuel economy level that the Secretary decides the manufacturers can achieve in that model year,"[6] based on the agency's consideration of four statutory factors: (1) technological feasibility; (2) economic practicability; (3) the effect of other motor vehicle standards of the Government on fuel economy; and (4) the need of the United States to conserve energy.[7] EPCA does not define these factors or specify what weight to give each factor in balancing them. Instead, such considerations are left within the discretion of the Secretary of Transportation (as delegated to NHTSA). Accordingly, NHTSA considers these factors in light of the circumstances present at the time of promulgating CAFE standards in setting maximum feasible standards. EPCA also contains requirements that prohibit NHTSA from considering certain factors when setting CAFE standards. In determining maximum feasible fuel economy levels, "the Secretary of Transportation—(1) may not consider the fuel economy of dedicated automobiles; (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."[8]

This proposed rule would, if finalized, revise existing CAFE standards for MYs 2022-2031 light-duty vehicles. This regulatory analysis examines the costs and benefits of proposed alternative CAFE standards for passenger cars and light trucks for MYs 2027-2031. NHTSA did not consider or estimate any impacts from the proposed changes in the standards for MYs 2022-2026 in this PRIA because no change in manufacturer behavior is possible for those years and, accordingly, the only effective impact would be on a manufacturer's compliance relative to the proposed standard.[9] At the time of the proposal, manufacturers have already produced fleets for MYs 2022-2025, either partially or completely. Furthermore, manufacturers have already made vehicle design decisions related to their MY 2026 fleets, leaving them limited options to adjust their production for that year in response to the proposed standards. As a result, NHTSA's proposed standards

[1] Pub. L. 94-163, 89 Stat. 817 (Dec. 22, 1975). https://www.govinfo.gov/content/pkg/STATUTE-89/pdf/STATUTE-89-Pg871.pdf.
[2] Pub. L. 110-140, 121 Stat. 1492 (Dec. 19, 2007). https://www.govinfo.gov/content/pkg/STATUTE-121/pdf/STATUTE-121-Pg1492.pdf.
[3] Other relevant legislation includes the Alternative Motor Fuels Act of 1988 (AMFA), Pub. L. 100-494, 102 Stat. 2441 (Oct. 14, 1988). https://www.govinfo.gov/content/pkg/STATUTE-102/pdf/STATUTE-102-Pg2441.pdf; the Energy Policy Act of 1992, Pub. L. 102-486, 106 Stat. 2776 (Oct. 24, 1992). https://www.govinfo.gov/content/pkg/STATUTE-106/pdf/STATUTE-106-Pg2776.pdf; and more recently One Big Beautiful Bill Act of 2025 (OB3), Pub. L. 119-21, 139 Stat. 72 (July 4, 2025). https://www.congress.gov/119/plaws/publ21/PLAW-119publ21.pdf.
[4] See preamble Section V.A for a complete discussion of the statutory provisions applicable to NHTSA's decision-making.
[5] 49 U.S.C. 32902(b)(1). EPCA uses the terms "passenger automobile" and "non-passenger automobile," while NHTSA uses the regulatory terms "passenger car" and "light truck," but they are intended to be used interchangeably.
[6] 49 U.S.C. 32902(a).
[7] 49 U.S.C. 32902(f).
[8] 49 U.S.C. 32902(h).
[9] The proposed alternative standards do result in changes to manufacturers' compliance position for the existing fleets in the model years that have passed. However, because the current civil penalty rate is set to $0, there are no monetized effects from their changing CAFE compliance positions.

are expected to have no impact on manufacturers' production decisions. Similarly, new vehicles produced for MYs 2022-2024 have already been purchased, as have, at the time of this proposal, most new vehicles produced in MY 2025. While manufacturers may adjust prices for vehicles produced in MYs 2025-2026 in response to the proposed standards, modeling such price changes would require significant speculation about how manufacturers will make decisions regarding their pricing strategies. Accordingly, without data for MYs 2025-2026 in hand, NHTSA performed sensitivity cases using the CAFE Model to generate estimated fleet average CAFE standards for MYs 2025-2026. NHTSA's consideration of the possible alternatives for MYs 2022-2026 is discussed in preamble Section III.

This PRIA examines the costs and benefits of various alternatives for setting fuel economy standards for PCs and light trucks for MYs 2027-2031.[10] The assessment includes a discussion of the technologies that can improve fuel economy, as well as an analysis of the potential impacts on vehicle retail prices; lifetime fuel savings and their value to consumers and other consumer responses to the standards; and other societal effects, such as energy security, changes in pollutant emissions levels, and safety. The assumptions informing these estimates are discussed in more detail in the Draft Technical Support Document (Draft TSD) and other accompanying documents. This analysis does not contain NHTSA's assessment of the potential environmental impacts of the regulatory alternatives for purposes of compliance with the National Environmental Policy Act (NEPA); rather, that analysis is contained in the agency's Draft Environmental Impact Statement (EIS) accompanying the proposed rule.

In coordination with the U.S. Department of Transportation (DOT) Volpe National Transportation Systems Center (Volpe or the Volpe Center), NHTSA uses the CAFE Compliance and Effects Modeling System (the "CAFE Model" or "the Model") to simulate and analyze manufacturers' potential responses to new CAFE standards and to estimate various impacts of those responses. NHTSA and Volpe coordinate to ensure that the CAFE Model's operation reflects the statutory considerations noted above.

NHTSA examined three regulatory alternatives, shown in

Table 1-1 below: a High Alternative 3, a Low Alternative 1, and a Preferred Alternative 2. For a detailed discussion of how these alternatives were developed, please see preamble Section III. For more details on the coefficient values included in the mathematical functions that define the alternatives, please see Chapter 3. The Preferred Alternative may also be referred to as the "proposed standards" throughout the rulemaking documents. NHTSA tentatively believed that the Preferred Alternative represents the maximum feasible fuel economy standards in the model years under consideration for the passenger car and light truck fleets, consistent with the statutory factors established by EPCA and EISA, when not considering the availability of statutorily proscribed technologies or programs.

Table 1-1: Regulatory Alternatives Under Consideration for MYs 2022-2031 Automobile Fleets

Name of Alternative	Passenger Car Stringency Changes	Light Truck Stringency Changes
No-Action Alternative	1.5% for MY 2023 8% per year for MYs 2024-2025 10% for MY 2026 2% per year for MYs 2027-2031	1.5% for MY 2023 8% per year for MYs 2024-2025 10% for MY 2026 0% per year for MYs 2027-2028 2% per year for MYs 2029-2031
Alternative 1	80% compliance share* MY 2022 0.50% per year for MYs 2023-2026 0.1% for MY 2027 0.3% for MY 2028** 0.25% per year for MYs 2029-2031	80% compliance share* MY 2022 0.50% per year for MYs 2023-2026 0.8% for MY 2027 0.6% for MY 2028** 0.25% per year for MYs 2029-2031
Alternative 2 (Preferred)	75% compliance share* MY 2022 0.50% per year for MYs 2023-2026 0.35% for MY 2027 0.25% for MY 2028**	70% compliance share* MY 2022 0.50% per year for MYs 2023-2026 0.7% for MY 2027 0.25% for MY 2028**

[10] Throughout this PRIA, cost and benefit analyses generally are presented for individual model years as well as the cumulative total for all model years through MY 2031 for passenger cars and light trucks. Some physical effects are presented on a calendar year basis through CY 2050 or another calendar year, as appropriate.

	0.25% per year for MYs 2029-2031	0.25% per year for MYs 2029-2031
Alternative 3	70% compliance share* MY 2022 0.50% per year for MYs 2023-2026 1.4% for MY 2027 1.5% for MY 2028** 1% per year for MYs 2029-2031	50% compliance share* MY 2022 0.50% per year for MYs 2023-2026 0.4% for MY 2027 0.2% for MY 2028** 1% per year for MYs 2029-2031

* Compliance shares were determined based on the production-weighted share of vehicles that met or exceeded their target function value for each regulatory alternative in MY 2022.

** Stringency change reflects the growth rate in class average standard value from MY 2027 to MY 2028.

NHTSA constructed a detailed representation of the MY 2024 passenger car and light truck fleet as a starting point to evaluate the costs and benefits of the proposed rule. For each of 4,264 specific vehicle model/configurations in the MY 2024 fleet, NHTSA obtained information, including production volumes, fuel economy/efficiency ratings, dimensions, curb weight and gross vehicle weight rating (GVWR), engine characteristics, transmission characteristics, and other key engineering information. NHTSA then simulated manufacturers' year-by-year application of technologies to those vehicles through MY 2050 based on standards defining each regulatory alternative.[11] For this analysis, the No-Action Alternative assumes that both the CAFE standards finalized in 2022 and 2024 and current programmatic elements like the off-cycle (OC) and air conditioning (AC) efficiency programs remain in effect. The No-Action Alternative also assumes that vehicles remain subject to the current classification (e.g., passenger car and light truck) regulatory definitions throughout the analysis years. Manufacturer responses in both the No-Action Alternative and the action alternatives include some technology adoption in response to new vehicle buyers' assumed willingness to pay for a portion of the fuel savings expected to occur over vehicles' lifetimes. The action alternatives also include manufacturers' simulated responses to existing standards in MYs 2025-2026 because, while the agency assumes industry has already produced or planned these model years, NHTSA must estimate the composition of those model year fleets to allow simulation of MYs 2027 and beyond.

A key indicator of individual, or consumer, cost effects for the analysis is the per-vehicle regulatory cost. The regulatory cost represents a summation of vehicle costs caused by changes in vehicle technology and passing on of any fines incurred by manufacturer shortfalls. Under current laws, NHTSA assumes there will be no fines for manufacturer shortfalls; therefore, only technology costs will be incurred in this analysis.[12] As summarized in Table 1-2, NHTSA projects that under the Preferred Alternative, technology costs, summed over the entire fleet, could decrease by $11 billion relative to the No-Action Alternative through MY 2031, assuming all manufacturers will attempt to meet standards with all practicable effort. If those savings are passed on to consumers (rather than, for example, to shareholders as increased gains, or to employees as increased compensation), NHTSA estimates that per-vehicle costs paid by consumers for new vehicles would be reduced by $925 in MY 2031, on average, compared to the No-Action Alternative.

Table 1-2: Estimated Regulatory Costs Relative to No-Action Alternative, MY 2031

	Total Regulatory Cost Savings ($b)	Per-vehicle Regulatory Cost Savings ($)
Alternative 1	11	925
Alternative 2	11	925
Alternative 3	10	847

Overall total societal cost reductions attributable to the Preferred Alternative standards over the lifetime of vehicles manufactured through MY 2031 relative to the No-Action Alternative are $109 billion at a 3-percent discount rate and $76 billion at a 7-percent discount rate. These estimates could change with different

[11] As in prior analyses, the analysis for this proposed rule exercises the CAFE Model using inputs that extend the explicit compliance simulation through MY 2050—many years beyond the last year for which NHTSA is proposing standards. This has been done because interactions between the new and used vehicles markets impact benefits and costs over the lives of vehicles produced in the rulemaking timeframe.

[12] See Chapter 8.2.2.3 for all Compliance Cost information.

assumptions; NHTSA's assessment of how different assumptions may change the analysis results are discussed in detail in Chapter 9 of this PRIA.

Table 1-3 and Table 1-4 below represent the different regulatory alternatives considered.

Table 1-3: Estimated Monetized Costs and Benefits – Model Year Perspective, Billions of 2024$

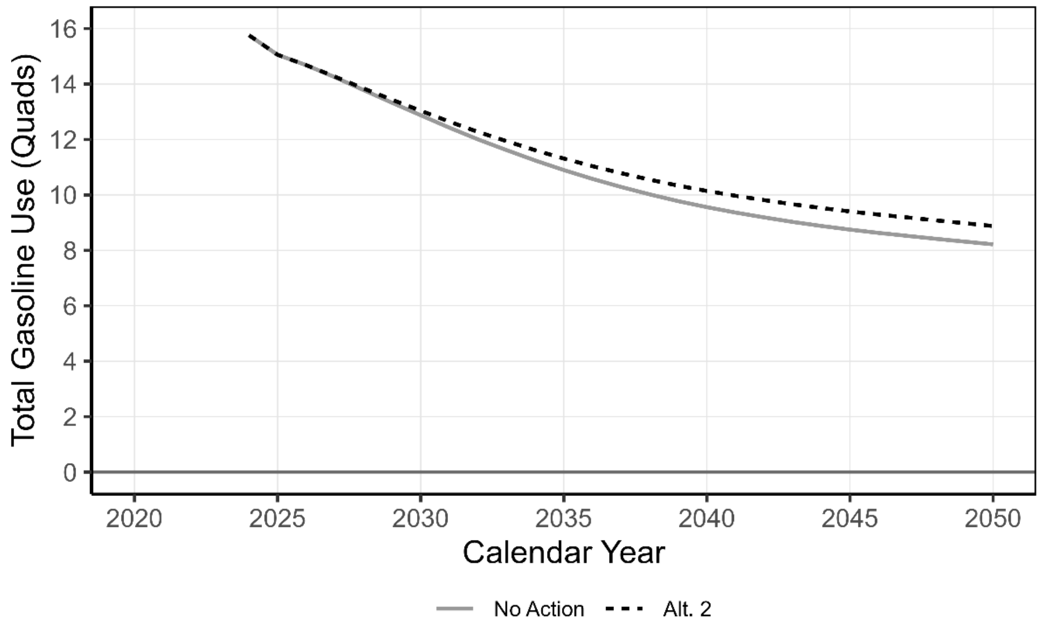
	Total			Annualized		
	Monetized Benefits	Monetized Costs	Monetized Net Benefits	Monetized Benefits	Monetized Costs	Monetized Net Benefits
3% Discount Rate						
Alternative 1	-85	-109	+24.0	-3.4	-4.4	1.0
Alternative 2	-85	-109	+24.0	-3.4	-4.4	1.0
Alternative 3	-73	-97	+23.7	-2.9	-3.9	0.9
7% Discount Rate						
Alternative 1	-54	-76	+22.2	-3.9	-5.6	1.6
Alternative 2	-54	-76	+22.2	-3.9	-5.6	1.6
Alternative 3	-47	-68	+21.2	-3.4	-4.9	1.6

Table 1-4: Estimated Monetized Costs and Benefits – Calendar Year Perspective, billions of 2024$

	Total			Annualized		
	Monetized Benefits	Monetized Costs	Monetized Net Benefits	Monetized Benefits	Monetized Costs	Monetized Net Benefits
3% Discount Rate						
Alternative 1	-291	-394	+102.8	-15.9	-21.5	5.6
Alternative 2	-291	-394	+102.8	-15.9	-21.5	5.6
Alternative 3	-257	-354	+97.3	-14.0	-19.3	5.3
7% Discount Rate						
Alternative 1	-157	-220	+62.1	-13.1	-18.3	5.2
Alternative 2	-157	-220	+62.1	-13.1	-18.3	5.2
Alternative 3	-138	-197	+58.8	-11.5	-16.4	4.9

NHTSA estimates that the Preferred Alternative stringency changes would increase gasoline consumption through calendar year (CY) 2050 by approximately 3.7 percent relative to projected consumption under the No-Action Alternative. Figure 1-1 shows the total change in gasoline energy use in comparison to the No-Action Alternative; 1 Quad is equivalent to 10^{15} British thermal units of energy.

Figure 1-1: Decreased Gasoline Energy Usage by the Preferred Alternative Compared to the No-Action Alternative



For simplicity, projected regulatory impacts presented in this document are referenced against the No-Action Alternative unless otherwise stated. The results of the analysis are set forth in the rest of this document.

2. The Need to Reset CAFE Standards

In accordance with Section 1(a) of E.O. 12866 and Section B of Circular A-4 (2003) issued by the White House Office of Management and Budget (OMB), this section outlines the need for Federal regulatory action on vehicle fuel economy.[13] Section B states that if agency regulation results from a statutory or judicial directive, the agency should describe:

- the specific authority for its action,
- the extent of discretion available to the agency, and
- the regulatory instruments the agency might use.[14]

The specific authority for this action is 49 U.S.C. 32902(a) and (b), which direct the Secretary of Transportation (by delegation, NHTSA) to prescribe by regulation average fuel economy standards for passenger cars and light trucks for each model year and to set those standards at the level the Secretary determines is the maximum feasible average fuel economy for that model year based on four factors enumerated in the statute: 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.

Congress required NHTSA to set CAFE standards for each model year and gave the agency discretion in applying and balancing the four statutory factors that inform the determination of maximum feasibility. In addition, Congress stated that NHTSA must set fuel economy standards based on an attribute related to fuel economy and express those standards in the form of a mathematical function.

E.O. 12866 states that agencies must identify the problem they intend to address, including, where applicable, the failures of private markets or public institutions (also referred to in OMB Circular A-4 as “other social purposes”) that warrant new agency action, and to as assess the significance of the problem.[15] Agencies are required to examine whether existing regulations (or other law) have created, or contributed to, the problem that a new regulation is intended to correct and whether those regulations (or other law) should be modified to achieve the intended goal of regulation more effectively.[16]

In accordance with E.O. 12866, this proposed rule resets previously established CAFE standards for MYs 2022-2031 passenger cars and light trucks addressing issues associated with the improper setting of the previously adopted standards. The proposed action also meets NHTSA’s obligation to establish fuel economy standards for passenger cars and light trucks, and to set standards at their maximum feasible level for each model year.

Unlike NHTSA’s previous regulatory actions establishing fuel economy standards, this proposal does not attempt to address market failures that affect the level of fuel economy buyers of new cars and light trucks choose beyond the statutory factors informing the setting of maximum feasible standards. Instead, this action is intended to alleviate distortions in the market for new cars and light trucks and in the makeup of the Nation’s light duty vehicle fleet that have been caused in part by the agency’s previous reliance on CAFE standards to redress problems they were not intended or designed to remedy. This proposed rule resets previously established CAFE standards at levels that will reduce those distortions and their effects on consumers and the U.S. economy while requiring continual fuel economy improvements in the light-duty fleet.

The following sections discuss the market failures and other social purposes that NHTSA has previously used to justify prior increases in CAFE standards as background to the discussion of how this specific proposal achieves the intended goal of more effective regulation.

[13] E.O. 12866 of September 30, 1993, Regulatory Planning and Review; Office of Management and Budget, Circular A-4 (Sept. 17, 2003), available at: https://www.whitehouse.gov/wp-content/uploads/2025/08/CircularA-4.pdf (accessed Sept. 10, 2025) (hereinafter, “OMB Circular A-4”).
[14] OMB Circular A-4 (Sept. 17, 2003).
[15] E.O. 12866 of September 30, 1993, Section 1(b)(1).
[16] E.O. 12866 of September 30, 1993, Section 1(b)(2).

2.1. Market Failures Considered in Previous CAFE Standards

OMB Circular A-4 describes the major types of market failure as, including externalities, market power, and inadequate or asymmetric information, and defines “other social purposes” for regulation to include improving the functioning of government, removing distributional unfairness, or promoting privacy and personal freedom. While NHTSA is required by law to establish fuel economy standards, the agency’s past rules have identified various energy security, consumer-related, and health and environmental market failures it believed could be mitigated by increasing fuel economy standards. However, establishing increasingly stringent CAFE standards has also distorted the market for new cars and light trucks and altered the makeup of the vehicle fleet in ways that have had adverse impacts on consumers and the public.

The following sections describe in more detail the potential market failures that the agency previously has found persuasive to address (or considered and then rejected) when justifying past increases in CAFE standards. While these market failures are not the exclusive justification for regulation—as discussed above, NHTSA’s standards must be set at maximum feasible levels considering the four section 32902(f) factors—NHTSA has relied heavily on these market failures as part of the justification for sustained, rapid increases in CAFE standards.

2.1.1. Energy Security Externalities

Congress’ primary focus in adopting CAFE standards and the other energy conservation measures as part of the 1975 EPCA legislation was to reduce the Nation’s reliance on imported oil to protect consumers and businesses from repeatedly experiencing the severe disruptions the Organization of the Petroleum Exporting Countries cartel’s boycott of exports to the United States had caused. Congress was concerned about the broader economic, geopolitical, and national security consequences of foreign producers’ ability to disrupt oil supplies and raise prices. By conserving fuel and thus reducing domestic petroleum consumption and imports, minimum fuel economy standards could be a means to reduce these effects, which came to be known as “energy security externalities.”

Analysts quantified three specific effects that domestic petroleum consumption and imports could have on the U.S. economy and developed measures of their economic costs. Beginning in the mid-2000s, NHTSA’s regulatory analyses supporting increases in CAFE standards included quantitative estimates of anticipated reductions in the economic costs those effects generated.[17] First, beyond their direct effects on spending for imports, changes in domestic gasoline consumption may affect global petroleum prices because the United States accounts for such a large share of worldwide demand. Changes in oil prices generate large transfers of revenue between consumers of petroleum products and oil producers, and as long as the United States remained a large oil importer, increases in domestic demand and global prices resulted in that revenue being transferred from domestic consumers to foreign oil suppliers. These transfers simply shift resources and produce no change in global economic output or welfare, but their financial drain on the U.S. economy is large and analysts argue that buyers of petroleum products are unlikely to consider their burden on the U.S. economy from consuming more oil. Reducing this burden is often described as a positive outcome of controlling U.S. petroleum consumption and imports, though the agency’s view is that reducing financial transfers does not provide real economic benefits in itself. In addition, since that time, the United States has dramatically increased domestic extraction of petroleum, which has, in turn, increased the overall global supply of petroleum. Today, the United States is a net petroleum exporter, meaning these revenue transfers now flow largely to domestic rather than foreign oil producers.

Increased U.S. consumption of refined petroleum products such as gasoline can also heighten the consequences of any rapid changes in oil prices or interruptions in its supply for other domestic petroleum users, whose consumption remains unaffected by changing CAFE standards. Because drivers are unlikely to consider any effect their gasoline use has on other consumers’ exposure to potential disruptions in oil supplies or rapid swings in its price, the increased risk associated with higher consumption is often cited as another external cost of increased U.S. petroleum consumption that CAFE standards could impact. NHTSA adapted methods from published research to estimate changes in these risks and their costs resulting from

[17] NHTSA, Average Fuel Economy Standards for Light Trucks Model Years 2008-2011, Docket No. 2006-24306 (2006), available at: https://www.nhtsa.gov/sites/nhtsa.gov/files/2006finalrule.pdf (accessed: Sept. 10, 2025).

requiring higher automobile fuel economy and has consistently reported them as "energy security" benefits of raising CAFE standards.

Finally, some analysts have argued that much of U.S. military spending is specifically intended to secure petroleum imports and that those spending levels could be affected by changes in petroleum consumption resulting from adjusting CAFE standards, with the resulting reductions in defense outlays counted as benefits of raising CAFE standards to reduce oil imports. However, NHTSA has consistently viewed reductions in petroleum use of the size it projected from raising CAFE standards as unlikely to affect U.S. military spending, because the Nation's overseas presence is difficult to tailor to the level of oil imports and in any case serves a variety of other important political and strategic objectives.

Draft TSD Chapter 6.2.4 discusses in detail the mechanisms by which changing CAFE standards would affect these three impacts, highlighting macroeconomic risk (the one it considers to be an important consequence of domestic petroleum consumption and imports) and describing the agency's methods for estimating relevant economic costs.

2.1.2. Consumer Behavior

The EISA amended NHTSA's authority to set CAFE standards and required NHTSA to set separate attribute-based standards for passenger cars and light trucks for MYs 2011-2010 that increase ratably to achieve a combined fuel economy average for MY 2020 of at least 35 mpg for the total light duty fleet. For later years, EISA requires NHTSA to set maximum feasible standards.[18] By the time EISA was passed, it had been determined that the U.S. Environmental Protection Agency (EPA) had the authority to set carbon dioxide (CO_2) emission standards for light duty vehicles, and because CO_2 is a chemical byproduct of fuel combustion, its new standards corresponded directly to minimum fuel economy requirements. In 2009, the White House established a joint NHTSA-EPA program to set equivalent fuel economy and greenhouse gas emission standards through 2016 and later required NHTSA to harmonize its CAFE standards with the ambitious CO_2 emission limits EPA adopted for 2017-2025.[19]

EPA asserted that higher fuel economy standards were justified to correct consumer "myopia," or failure to consider the long-term value of savings in fuel costs from purchasing car and light truck models that offered improved fuel economy. It attributed car shoppers' "short-sightedness" to an extensive catalog of behavioral biases and cognitive deficiencies and asserted that imposing more stringent fuel economy requirements could counteract buyers' behavior. Regulatory analyses supporting EPA's emissions rules purported to identify large savings in fuel costs that buyers ostensibly failed to consider when choosing among competing models. Together with more modest economic benefits from reducing emissions, EPA reasoned, correcting consumers' behavior provided the economic justification for requiring higher fuel economy via sharply lower limits on CO_2 emissions.[20]

Echoing EPA's assertions, NHTSA assumed in its rulemaking analyses that car buyers considered only 25 to 30 percent of the savings in fuel costs a higher mpg car or light truck would achieve over its lifetime when they chose among competing models, but (together with any subsequent owners of the vehicles they purchased new) would ultimately receive the benefit of 100 percent of the discounted value of those savings. This phenomenon—again in conjunction with social benefits from reducing CO_2 emissions—helped provide the economic justification for significant increases in CAFE standards.

Table 2-1 summarizes recent studies that explore buyers' valuation of higher fuel economy using buyers' choices among competing models with varying purchase prices, fuel economy, and other attributes. These studies consistently suggest that, using conventional discount rates, buyers value a significant fraction of the

[18] U.S. Congress, The Energy Independence and Security Act of 2007, H.R. 6 (2007), available at: https://www.govinfo.gov/content/pkg/BILLS-110hr6enr/pdf/BILLS-110hr6enr.pdf (accessed: Sept. 10, 2025).
[19] EPA and DOT, Proposed Rulemaking to Establish Light-Duty Vehicle Greenhouse Gas Emission standards and Corporate Average Fuel Economy Standards, EPA–HQ–OAR–2009–0472; FRL–8959–4; NHTSA–2009–0059 (2009), available at: https://www.govinfo.gov/content/pkg/FR-2009-09-28/pdf/E9-22516.pdf (accessed: Sept. 10, 2025). Also see DOT, CAFE Standards, Last revised: Aug. 11, 2013, available at: https://www.transportation.gov/mission/sustainability/corporate-average-fuel-economy-cafe-standards?quot (accessed: Sept. 10, 2025).
[20] EPA and DOT, Final Rule for Model Year 2012-2016 Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards, EPA–HQ–OAR–2009–0472; FRL–9134–6; NHTSA–2009–0059 (2020), available at: https://www.govinfo.gov/content/pkg/FR-2010-05-07/pdf/2010-8159.pdf (accessed: Sept. 10, 2025).

future cost savings that models with higher fuel economy offer.[21] Accounting for differences in their data and estimation procedures, the studies summarized in the table suggest that car buyers value at least half—and perhaps much more—of savings in vehicles' lifetime fuel costs they expect from choosing models with higher fuel economy, with some concluding that consumers may *overvalue* these savings.[22]

Table 2-1: Percent of Future Fuel Costs Reflected in Vehicle Purchase Prices*

		Discount Rate			
Authors (Pub. Date)	**Scope**	**3%**	**5%**	**6%**	**10%**
Busse, Knittel, and Zettelmayer (2013)[23]**	New and used vehicles	54%-87%	60%-96%	62%-100%	73%-117%
Allcott and Wozny (2014)[24]	Used vehicles	48%		55%	65%
Sallee, West, and Fan (2016)[25]	New and used vehicles		101%		142%
Leard et al. (2023)[26]	New vehicles		69%		90%

Assumes current fuel prices reflect vehicle buyers' expectations for future prices.

**Ranges of estimates from Busse et al. (2013) depend on which quartiles of the fuel economy distribution are compared, so this table presents the full quartile comparison range.

[#] Central estimate of this value reported in Leard et al. (2023) is 53.6 percent using a discount rate of 1.3 percent. The authors report values using several alternative discount rates in their online appendix.[27]

The agency has reconsidered its prior assertion that a market failure exists preventing car buyers from properly taking future fuel savings into account. NHTSA believes that a more convincing explanation for buyers' apparent reluctance to choose vehicle models whose higher fuel economy would repay the initial price premiums is that consumers instead prefer to pay for other features—safety, comfort, performance, or carrying capacity. Sacrificing features many buyers value more highly than further increases in fuel economy reduces the attractiveness of these models. In NHTSA's view, this "opportunity cost" of compromises in features appears to be a more likely source of buyers' apparent hesitance to purchase higher fuel economy vehicle models than any consumer "myopia" in considering savings in their future fuel costs. The agency includes an estimate of the effect of resetting CAFE standards on the opportunity cost in its analysis, but notes that its estimate is limited to impacts to other vehicle attributes and likely does not fully account for costs imposed on consumers by limiting their choices. Chapter 6.1.3 of the Draft TSD discusses the origins and measurement of this opportunity cost in more detail.

[21] These studies relate changes over time in individual models' selling prices to fluctuations in fuel prices and differences in their fuel economy—which combine to change their remaining lifetime fuel costs, and thus presumably their market value—while controlling for increases in their age and accumulated mileage between subsequent sales (which affect vehicles' market values by shortening their expected remaining lifetimes). Comparing changes in individual models' actual selling prices to those that would be expected if their buyers fully valued the impact of changing fuel prices on future fuel costs can reveal the fraction of changes in their lifetime fuel costs that is reflected in their selling prices. Using very large samples of sales allows these studies to define vehicle models at an extremely disaggregate level, which enables their authors to isolate differences in their fuel economy from other attributes (including those that are difficult to observe or measure) that also affect their sale prices.

[22] Although the research summarized in Table 2-1 relies predominantly on changes in used vehicles' prices between repeat sales, most authors extend their estimates of buyers' valuation of changes in fuel costs to include new vehicles. Busse et al. find that consumers value from 75 to 133 percent of future fuel costs for new vehicles, higher fractions than they estimate for used vehicles, while Leard et al.'s results—which rely on a different estimation approach and data—suggest lower valuation of fuel cost savings among new-car buyers. When Leard et al. apply their methodology to the data used in Busse et al., they obtain results similar to those authors, yet when they apply their methodology to their own data, they find undervaluation comparable to their own baseline results, suggesting both results are sensitive to the sample period and data rather than methodology. Allcott and Wozny examine how their estimates vary by vehicle age and find that fluctuations in purchase prices of younger vehicles imply that buyers whose fuel price expectations mirror the petroleum futures market value a much higher fraction of future fuel costs: 93 percent for 1- to 3-year-old vehicles, compared to their estimate of 76 percent for all used vehicles assuming the same price expectation.

[23] Busse, M. R. et al., Are Consumers Myopic? Evidence From New and Used Car Purchases, *American Economic Review*, Vol. 103(1): pp. 220 – 56 (2013), available at: https://www.jstor.org/stable/23469641 (accessed: Sept. 10, 2025).

[24] Allcot, H., & Wozny, N., Gasoline Prices, Fuel Economy, and the Energy Paradox, *The Review of Economics and Statistics*, Vol. 96(5): pp. 779 – 95 (2014), available at: https://doi.org/10.1162/REST_a_00419 (accessed: Sept. 10, 2025).

[25] Sallee, J. et al., Do Consumers Recognize the Value of Fuel Economy? Evidence from Used Car Prices and Gasoline Price Fluctuations, *Journal of Public Economics,* Vol. 135: pp. 61 – 73 (2016), available at: https://www.sciencedirect.com/science/article/abs/pii/S0047272716000049 (accessed: Sept. 10, 2025).

[26] Leard, B. et al., How Much Do Consumers Value Fuel Economy and Performance? Evidence from Technology Adoption, *The Review of Economics and Statistics*, Vol. 105(1): pp. 158 – 74 (2023), available at: https://doi.org/10.1162/rest_a_01045 (accessed: Sept. 10, 2025) (hereinafter, "Leard et al. (2023)").

[27] See Appendix of Leard et al. (2023).

2.1.3. Health and Environmental Externalities

NHTSA has asserted previously that pollutants emitted by producing and using motor fuel may exemplify an externality because any potential associated costs and consequences may be borne by the public rather than by drivers whose vehicles potentially contribute to them. Vehicles' emissions of particulate matter (PM), nitrogen oxides (NO_X), and sulfur oxides (SO_X) contribute to local and regional air pollution, and widespread exposure to higher pollutant concentrations may in some circumstances adversely affect public health. Vehicle owners and manufacturers do not directly incur the costs of any environmental harm or health damages these emissions cause, so they have little incentive to reduce them. Regulating fuel economy is intended partly to reduce vehicle emissions as well as upstream emissions related to the production of automotive fuel and the damages they cause. Draft TSD Chapter 5.4 discusses further the health impacts from changes in criteria pollutant emissions.

NHTSA also has asserted previously that burning fossil fuels and the associated emissions of CO_2, methane (CH_4), and nitrous oxide (N_2O) may represent an additional example of an externality. In past rules, NHTSA and EPA have enacted sustained, rapid increases in emissions and fuel economy standards supported by a regulatory analysis that purported to show significant net benefits as a result of changes in emissions. However, as noted in E.O. 14154, these past practices are premised on an estimate "marked by logical deficiencies, a poor basis in empirical science, [and] politicization."[28] The Office of Information and Regulatory Affairs (OIRA) has also noted that there are significant uncertainties about how to "assess the relationship between verified anthropogenic changes in climate and the resulting environmental and economic impacts,"[29] and therefore it would be inappropriate to rely on these potential changes as a basis for regulating vehicle fuel efficiency. Furthermore, NHTSA notes that EPCA, as amended by EISA, was not designed to address possible changes in climate caused by vehicle emissions. For these reasons, while the agency is considering the potential of these effects, NHTSA is not monetizing these potential effects in its primary analysis. These potential effects are monetized, however, in sensitivity analyses.

2.2. How Does this Proposal Approach Fuel Economy?

Previously adopted CAFE standards have required manufacturers to achieve sustained, rapid increases in fuel economy levels that were justified in part by presumed market failures that may not exist or may no longer be significant. This proposed rule amends existing standards to remedy those distortions. Deferring or eliminating improvements in other features that new car and light truck buyers value and slowing the incorporation of new models into the Nation's vehicle fleet have impacted drivers and the public. These impacts have included narrowing the range of desired features available to potential buyers of new cars and light trucks by delaying improvements in attributes other than fuel economy, including features that can improve safety. While NHTSA estimates some of these impacts in its analysis of fuel economy standards (e.g., by estimating changes in vehicle prices and resulting sales), others are more difficult to quantify.

Requiring manufacturers to focus on continually improving fuel economy by setting demanding CAFE standards is likely to have distracted their attention and shifted their resources away from improving the safety of new cars and light trucks. Higher fuel economy standards have likely impacted vehicles in various ways, including vehicle attributes, footprint, and types offered. Manufacturers' costs to produce and integrate the additional technology required to improve fuel economy rapidly enough to meet constantly rising CAFE standards compete with those for developing and producing advanced systems to help drivers avoid crashes, and for continuing to improve the protection of vehicle occupants in crashes. Manufacturers must make careful tradeoffs among improvements in features that potential buyers value, and by requiring them to focus resources disproportionately on improving a single attribute—fuel economy—raising CAFE standards has led producers to slow or compromise planned improvements to those other features.

Notwithstanding likely reduced investments in other attributes, costs to meet progressively higher CAFE standards have also forced manufacturers to raise prices for new cars and light trucks, thus reducing sales of new models and prompting many owners to keep their used cars in service longer. Due to CAFE standards

[28] Section 6(c) of E.O. 14154.

[29] Executive Office of the President. Guidance Implementing Section 6 of E.O. 14154, Entitled "Unleashing American Energy," M-25-27 (2025), available at: https://www.whitehouse.gov/wp-content/uploads/2025/02/M-25-27-Guidance-Implementing-Section-6-of-Executive-Order-14154-Entitled-Unleashing-American-Energy.pdf (accessed: Sept. 10, 2025).

and other factors, the average selling price for new cars and light trucks has risen nearly 50 percent between 2012 and 2024 and now approaches $50,000,[30] more than double the increase in U.S. households' average income over that same period.[31] These increased prices create enormous consequential financial burdens, as finance charges, taxes, insurance costs, and registration fees almost always increase along with the selling price of a new vehicle. To accommodate these additional costs, families have stretched their installment contracts over a significantly longer period to lower monthly payments—which results in an even larger finance charge over time. Between 2008 and 2023, the most common new vehicle retail installment contract term increased from 60 months to 72 months, with 84-month contracts becoming increasingly common.[32] And as term length increases, so does the associated interest rate—approximately 1.2 points higher between 60 and 72 months.[33] As a consequence, the financial burden on households to purchase a new vehicle has increased substantially, and recent annual sales of new cars and light trucks have been slightly *lower* than they were immediately before and after the 2008-2010 recession, generally, but particularly so on a per-capita or per-licensed driver basis. Meanwhile, the total number of cars and light trucks in use rose by about 30 million, with the entire increase representing used vehicles, while their average age rose from 10.6 to 12.6 years.[34]

Lower sales of new cars and light trucks have slowed the introduction of safer new vehicles into the fleet, and, partly as a consequence, the long-term historical decline in fatalities and serious injuries caused by motor vehicle crashes has slowed dramatically over the same period that CAFE standards have risen rapidly.[35] Delaying the retirement of older cars and light trucks and slowing their replacement with new models in effect shifts some driving from new to older vehicles, which may also have contributed to the slower pace of recent improvements in safety.

This proposed reset of previously adopted CAFE standards reduces manufacturers' costs to meet future targets for improved fuel economy and, by doing so, slows any increase in prices for new cars and light trucks attributable to CAFE obligations. In turn, this raises sales compared to the levels the agency projected would result from adopting those original standards, accelerate the retirement of older vehicles and their replacement by new models, and, if manufacturers choose to do so, broaden the array of desirable features that new car and light truck models offer to potential buyers. An even more important consequence is that resetting CAFE standards will enable manufacturers to speed the development and integration of new crash avoidance and other safety-improving technologies into new car and light truck models, which should help to improve the safety of motor vehicle travel for all road users.

This PRIA estimates economic benefits and costs from resetting previous CAFE standards and reducing the rate at which future fuel economy targets rise. These benefits include cost savings to manufacturers and the resulting lower selling prices for new cars and light trucks, increased sales of new models, and earlier retirement of old vehicles. Instead of prioritizing fuel economy exclusively, the design of new car and light truck models will emphasize improvements to features their buyers value most. Safer new cars and light

[30] Cox Automotive, Kelley Blue Book Report: Average New-Vehicle Prices Climb Higher For Fourth Consecutive Month, Flirt With All-Time High, Last revised: Jan. 15, 2025, available at: https://mediaroom.kbb.com/2025-01-15-Kelley-Blue-Book-Report-Average-New-Vehicle-Prices-Climb-Higher (accessed: Sept. 10, 2025).

[31] U.S. Census Bureau, Current Population Survey, 1981 to 2024 Annual Social and Economic Supplements (CPS ASEC), Table H-9, Type of Household--All Households by Median and Mean Income: 1980 to 2023, available at: https://www.census.gov/data/tables/time-series/demo/income-poverty/historical-income-households.html (accessed: Sept. 10, 2025).

[32] Katcher et al., One Month Longer, One Month Later? Prepayments in the Auto Loan Market Federal Reserve Board, Board of Governors of the Federal Reserve System: Washington, DC, p. 9 (2024), available at: https://www.federalreserve.gov/econres/feds/files/2024056pap.pdf (accessed: Sept. 10, 2025).

[33] *Id.*, at pp. 12 – 13.

[34] From 2010 to 2024, the number of U.S. households and the Nation's driving-age population each rose about 12 percent, while sales of new cars and light trucks during 2024 were slightly lower or about the same (13-15 million) as during most years immediately before and after the Great Recession of 2008-10. The total number of cars and light trucks in use grew from 230 million in 2010 to 260 million in 2023. Sources: FRED (Federal Reserve Bank of St. Louis), Total Households, Last revised: Nov. 12, 2024, available at: https://fred.stlouisfed.org/series/TTLHH (accessed: Sept. 10, 2025); FRED (Federal Reserve Bank of St. Louis), Population - With No Disability, 16 Years and over (LNU00074593), Last revised: Sept. 5, 2025, available at: https://fred.stlouisfed.org/series/LNU00074593 (accessed: Sept. 10, 2025); and Federal Highway Administration, Highway Statistics Series, Last revised: June 2, 2025, available at: https://www.fhwa.dot.gov/policyinformation/statistics.cfm#:~:text=The%20Highway%20Statistics%20Series%20consists%20of%20annual%20reports,charts.%20It%20has%20been%20published%20annually%20since%201945 (accessed: Sept. 10, 2025) for Highway Statistics 2010 and 2023 editions, Table VM-1.

[35] The data used to estimate NHTSA's safety models show that fatalities and serious injuries per million miles among occupants of new cars and light trucks are only about half those of 10- to 20-year old models. Fatalities and serious injuries per million miles among occupants of all (new plus used) cars and light trucks each declined by 3.3 percent annually between 1990 and 2010, but have not declined substantially further (in fact, they have risen in recent years) since then. Sources: FARS, NHTSA Traffic Safety Facts, various editions, and FHWA, Highway Statistics, various editions, Table VM-1.

trucks will be absorbed into the fleet and replace older vehicles more rapidly, and the advanced safety technologies new models offer will help to reduce crashes and injuries to their occupants, as well as vulnerable road users and occupants of other vehicles.

Resetting CAFE standards may also result in higher fuel consumption by new vehicles, though only when compared to their fuel use under previously adopted standards; the fuel economy new cars and light trucks offer is expected continue to increase from its already historically high recent levels. New models will need to be refueled slightly more frequently, and the risk of economic disruptions from sudden increases in global oil prices may rise marginally. NHTSA details its balancing of these potential consequences and other statutorily required factors in setting maximum feasible fuel economy standards in Section V of the preamble. Other chapters of this regulatory analysis explain in detail the methods and assumptions the agency uses to estimate the costs and benefits of this proposal.

3. Regulatory Alternatives Considered for Passenger Cars and Light Trucks

CAFE Model Files Referenced in this Chapter

Below is a list of CAFE Model Files referenced in this chapter. See Draft TSD Chapter 2.1.9 titled "Where to Find the Internal NHTSA Files" for a full list of files referenced in this document and their respective file locations.

- Market Data Input File
- Scenarios Input File

NHTSA considers regulatory alternatives in rulemaking analyses as a way of evaluating the comparative effects of different potential ways of accomplishing its desired goal, which in this case is to fulfill the statutory mandate to set maximum feasible standards. E.O. 12866 and E.O. 13563, as well as OMB Circular A-4, also encourage agencies to 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 regulatory action by the agency—in other words, the baseline. 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 the market;
- Changes in external factors affecting expected benefits and costs;
- Changes in regulations promulgated by the agency or other government entities; and
- The degree of compliance by regulated entities with other regulations.[36]

For this proposal, NHTSA developed separate alternatives for two distinct periods of time (MYs 2022-2026 and MYs 2027-2031) and two distinct fleets (passenger cars and light trucks). NHTSA developed 16 total alternatives: No-Action and 3 action alternatives for passenger cars for MYs 2022-2026; No-Action and 3 action alternatives for light trucks for MYs 2022-2026; No-Action and 3 action alternatives for passenger cars for MYs 2027-2031; and No-Action and 3 action alternatives for light trucks for MYs 2027-2031. The proposed standards may, in places, be referred to as the "Preferred Alternative(s)," but NHTSA intends "proposed standards" and "Preferred Alternative(s)" to be used interchangeably for purposes of this document.

Each action alternative sets stringency levels for each model year that can be defined in terms of percent-changes in stringency from year to year; however, these changes differ slightly between passenger cars and light trucks for each of the time periods. Also, year-over-year changes in stringency generally are *not* measured in terms of mile-per-gallon differences (as in, 1 percent more stringent than 30 miles per gallon (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 of 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). The footprint functions for the standards are as follows:

Equation 3-1: Passenger Car Fuel Economy Footprint Target Curve

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

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 maximum fuel economy target (in mpg);

[36] OMB Circular A-4, General Issues, 2, Developing a Baseline.

b is a minimum fuel economy target (in mpg);

c is the slope (in gallons per mile (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.

Equation 3-2: Light Truck Fuel Economy Footprint Target Curve

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

Where:

$TARGET_{FE}$ is the fuel economy target (in mpg) applicable to a specific vehicle model type with a unique footprint combination. Parameters *a*, *b*, *c*, and *d* are defined as for passenger cars but take values specific to non-passenger automobiles.

The exception to defining action alternatives in terms of yearly stringency changes occurs in the transition from MYs 2027-2028, when NHTSA is proposing to change the regulatory classifications for non-passenger automobiles.[37] Because NHTSA uses a different set of initial footprint curve parameters (i.e., slope, intercept, and cutpoints) for each fleet starting in MY 2028, the change in stringency from MYs 2027-2028 cannot be defined using multiplication by a common factor. Instead, NHTSA first applied a year-over-year stringency adjustment to each proposed alternative in MY 2027 to generate initial target function parameters for MY 2028 for each class variable "m," as shown in Equation 3-3.

Equation 3-3: Scaling Equations for Initial MY 2028 Target Function Parameters

$$a_{2028,0}^{m} = \frac{1}{k_1} \times a_{2027}^{m}$$
$$b_{2028,0}^{m} = \frac{1}{k_1} \times b_{2027}^{m}$$
$$c_{2028,0}^{m} = k_1\, c_{2027}^{m}$$
$$d_{2028,0}^{m} = k_1\, d_{2027}^{m}$$
$$k_1 = 1 - \Delta_{2028}$$

Here,"Δ_{2028}" equals the percentage year-to-year change in stringency from MYs 2027-2028 in a given alternative. Because the target functions slope and intercept are defined in units of gpm, an increase in stringency corresponds to a downward shift in the slope and intercept of the function, while a lower stringency corresponds to an increase in these terms. The agency then determined the regulatory class (i.e., passenger cars and light trucks) average standards "$\mathrm{STANDARD}_{2028}^{m,0}$" for each regulatory class using the MY 2024 initial fleet under the fleet's classification in MY 2027, as shown in Equation 3-4.

Equation 3-4: Determination of MY 2028 Class Average Standards Under Initial Classification

$$\mathrm{STANDARD}_{2028}^{m,0} = \frac{n_{m,0}}{\sum_{j=1}^{n_{m,0}} \frac{1}{TARGET_j^{2028,0}}}$$

$$TARGET_j^{2028,0} \frac{1}{MIN\left[MAX\left(c_{2028,0} \times FOOTPRINT_j + d_{2028,0}, \frac{1}{a_{2028,0}}\right), \frac{1}{b_{2028,0}}\right]}$$

[37] See Chapter 2.7.2 of the Draft TSD for a more detailed discussion of how NHTSA adjusted the methodology to categorize an automobile as a passenger automobile (i.e., passenger car) or non-passenger automobile (i.e., light truck). NHTSA also frequently uses "passenger vehicle."

Here “$n_{m,0}$” equals the total number of automobiles produced in class “m” according to the initial classification. NHTSA then performed an analogous calculation to determine “$\mathrm{STANDARD}_{2028}^{m,A}$”—the class average standard—using the alternative classification and the initial parameter estimates as described in Chapter 1 of the Draft TSD. This is shown in Equation 3-5.

Equation 3-5: Determination of MY 2028 Class Average Stringencies Under Alternative Classification using Alternative Parameter Estimates

$$\mathrm{STANDARD}_{2028}^{m,A} = \frac{n_{m,A}}{\sum_{j=1}^{n_{m,A}} \frac{1}{TARGET_j^{2028,A}}}$$

$$TARGET_j^{2028,A} \frac{1}{MIN\ [MAX\left(c_{2028,A} \times FOOTPRINT_j + d_{2028,A}, \frac{1}{a_{2028,A}}\right), \frac{1}{b_{2028,A}}]}$$

The class averages can then be used to generate a ratio, which is used as a scaling factor to generate the final target function coefficients in each alternative, as shown in Equation 3-6.

Equation 3-6: Scaling Equations for Final MY 2028 Target Function Parameters

$$a_{2028}^{m} = \frac{1}{k_2} \times a_{2028,A}^{m}$$
$$b_{2028}^{m} = \frac{1}{k_2} \times b_{2028,A}^{m}$$
$$c_{2028}^{m} = k_2 c_{2028,A}^{m}$$
$$d_{2028}^{m} = k_2 d_{2028,A}^{m}$$

$$k_2 = \frac{\mathrm{STANDARD}_{2028}^{m,A}}{\mathrm{STANDARD}_{2028}^{m,0}}$$

This process ensures that a change in target function shape preserves the year-to-year change in stringency “Δ_{2028}” for the class.

The resultant functional form is reflected in graphs displaying the passenger car and light truck target functions in each model year for each regulatory alternative in preamble Sections IV.B.1 and IV.B.3.

For this proposal, NHTSA applied individual rates of change to the passenger car and the light truck fleets in different model years in some of the action alternatives. In the Preferred Alternative, the respective standards for both fleets change at the same rate. However, the two remaining action alternatives evaluated for this proposal have passenger car fleet rates-of-change in fuel economy that are different from the rates-of-change in fuel economy for the light truck fleet. NHTSA has discretion, by law, to set CAFE standards that increase at different rates for passenger cars and light trucks because NHTSA must set maximum feasible CAFE standards separately for passenger cars and light trucks.[38]

[38] See the 2012 final rule establishing CAFE standards for MY 2017 and beyond, in which rates of stringency increase for passenger cars and LTs were different. 77 FR 62623, 62638-62639 (Oct. 15, 2012).

Table 3-1: Regulatory Alternatives Under Consideration for MYs 2022-2031 by Regulatory Class

Name of Alternative	Passenger Car Stringency Changes	Light Truck Stringency Changes
No-Action Alternative	1.5% for MY 2023 8% per year for MYs 2024-2025 10% for MY 2026 2% per year for MYs 2027-2031	1.5% for MY 2023 8% per year for MYs 2024-2025 10% for MY 2026 0% per year for MYs 2027-2028 2% per year for MYs 2029-2031
Alternative 1	80% compliance share* MY 2022 0.50% per year for MYs 2023-2026 0.1% for MY 2027 0.3% for MY 2028** 0.25% per year for MYs 2029-2031	80% compliance share* MY 2022 0.50% per year for MYs 2023-2026 0.8% for MY 2027 0.6% for MY 2028** 0.25% per year for MYs 2029-2031
Alternative 2 (Preferred)	75% compliance share* MY 2022 0.50% per year for MYs 2023-2026 0.35% for MY 2027 0.25% for MY 2028** 0.25% per year for MYs 2029-2031	70% compliance share* MY 2022 0.50% per year for MYs 2023-2026 0.7% for MY 2027 0.25% for MY 2028** 0.25% per year for MYs 2029-2031
Alternative 3	70% compliance share* MY 2022 0.50% per year for MYs 2023-2026 1.4% for MY 2027 1.5% for MY 2028** 1% per year for MYs 2029-2031	50% compliance share* MY 2022 0.50% per year for MYs 2023-2026 0.4% for MY 2027 0.2% for MY 2028** 1% per year for MYs 2029-2031

* Compliance shares were determined based on the production-weighted share of vehicles that met or exceeded their target function value for each regulatory alternative in MY 2022.

** Stringency change reflects the growth rate in class average standard value from MYs 2027-2028.

In Table 3-1, as noted, MY 2028 standards are adjusted to account for reclassification and to preserve the stringency increase. The following subchapters define each regulatory alternative (including the No-Action Alternative) by time period and provide details on how NHTSA developed them.

3.1. No-Action Alternatives for Passenger Cars and Light Trucks

3.1.1. No-Action Alternative for the MYs 2022-2026 Amendment

The analysis of the No-Action Alternative assumes the following:

- The following CAFE standards remain in place:
  - The CAFE standards for MYs 2022-2023 that were finalized in the 2020 final rule.[39]
  - The CAFE standards for MYs 2024-2026 that were finalized in the 2022 final rule.[40]
- The statutory limitations in 49 U.S.C. 32902(h) apply in all model years in the analysis:
  - The fuel economy of dedicated automobiles is not considered.
  - Dual-fueled automobiles are operated only on gasoline or diesel fuel.
  - The trading, transferring, or availability of credits is not considered.
- Manufacturers will have made their production decisions and will have produced vehicles through MY 2026 by the time this proposed rule will be published. Compliance for those vehicles would be based on actual CAFE performance.

Existing NHTSA standards during the rulemaking timeframe are analyzed as follows:

[39] 85 FR 24174 (Apr. 30, 2020).
[40] 87 FR 25710 (May 2, 2022).

The No-Action Alternative standards for the existing MYs 2022-2026 passenger car and light truck fleets are defined by the following coefficients, as shown in Table 3-2 and Table 3-3.

Table 3-2: Passenger Car CAFE Target Function Coefficients for the No-Action Alternative for the MYs 2022-2026 Amendment

	2022	2023	2024	2025	2026
a (mpg)	50.24	51.00	55.44	60.26	66.95
b (mpg)	37.59	38.16	41.48	45.08	50.09
c (gpm per s.f.)	0.00044662	0.00043992	0.00040473	0.00037235	0.00033512
d (gpm)	0.00159413	0.00157022	0.00144460	0.00132903	0.00119613

Table 3-3: Light Truck CAFE Target Function Coefficients for the No-Action Alternative for the MYs 2022-2026 Amendment

	2022	2023	2024	2025	2026
a (mpg)	40.31	40.93	44.48	48.35	53.73
b (mpg)	26.02	26.42	26.74	29.07	32.30
c (gpm per s.f.)	0.00049869	0.00049121	0.00045191	0.00041576	0.00037418
d (gpm)	0.00436016	0.00429476	0.00395118	0.00363509	0.00327158

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 import passenger automobile fleets manufactured for sale in the United States by all manufacturers in the model year. For the No-Action Alternative for MYs 2022-2026 shown on Table 3-4 the Minimum Domestic Passenger Car Standard (MDPCS) is applied as it was established in the 2020 and 2022 final rules. In its 2020 final rule, NHTSA began using an "offset" to adjust the MDPCS, starting with MY 2021. The offset accounts for recent projection errors as part of estimating the total passenger car fleet fuel economy and has been used in rulemakings since.

Table 3-4: No-Action Alternative – Minimum Domestic Passenger Car Standard (MPG) for the MYs 2022-2026 Amendment

2022	2023	2024	2025	2026
40.6	41.1	44.3	48.1	53.5

3.1.2. No-Action Alternative for the MYs 2027-2031 Amendment

The analysis of the No-Action Alternative assumes the following:

- The existing CAFE standards remain in place:
  - The CAFE standards for MYs 2024-2026 that were finalized in the 2022 final rule.[41]
  - The CAFE standards for MYs 2027-2031 that were finalized in the 2024 final rule.[42]
- The following statutory limitations in 49 U.S.C. 32902(h) apply in all model years in the analysis:
  - The fuel economy of dedicated automobiles is not considered.
  - Dual-fueled automobiles are operated only on gasoline or diesel fuel.
  - The trading, transfer, or availability of credits is not considered.

Existing NHTSA standards during the rulemaking timeframe are modeled as follows:

[41] 87 FR 25710 (May 2, 2022).
[42] 89 FR 52540 (June 24, 2024).

The No-Action Alternative standards for the existing MYs 2027-2031 passenger car and light truck fleets are defined by the following coefficients in Table 3-5 and Table 3-6, which (for purposes of this analysis) are assumed to persist without change in subsequent model years:

Table 3-5: Passenger Car CAFE Target Function Coefficients for the No-Action Alternative for the MYs 2027-2031 Amendment

	2027	2028	2029	2030	2031
a (mpg)	68.32	69.71	71.14	72.59	74.07
b (mpg)	51.12	52.16	53.22	54.31	55.42
c (gpm per s.f.)	0.00032841	0.00032184	0.00031541	0.00030910	0.00030292
d (gpm)	0.00117220	0.00114876	0.00112579	0.00110327	0.00108120

Table 3-6: Light Truck CAFE Target Function Coefficients for the No-Action Alternative for the MYs 2027-2031 Amendment

	2027	2028	2029	2030	2031
a (mpg)	53.73	53.73	54.82	55.94	57.08
b (mpg)	32.30	32.30	32.96	33.63	34.32
c (gpm per s.f.)	0.00037418	0.00037418	0.00036670	0.00035936	0.00035218
d (gpm)	0.00327158	0.00327158	0.00320615	0.00314202	0.00307918

For purposes of the No-Action Alternative, the MDPCS is applied as it was established in the 2024 final rules show in Table 3-7.

Table 3-7: No-Action Alternative – Minimum Domestic Passenger Car Standard (MPG) for the MYs 2027-2031 Amendment

2027	2028	2029	2030	2031
54.2	55.5	56.4	57.5	58.7

3.2. Action Alternatives for Passenger Cars and Light Trucks

In addition to the No-Action Alternative, NHTSA has considered three action alternatives for passenger cars and light trucks, each of which is less stringent than the No-Action Alternative during the rulemaking timeframe. These action alternatives are specified below and demonstrate different possible approaches to balancing the statutory factors applicable for setting fuel economy standards for passenger cars and light trucks. Section V of the preamble discusses in more detail how the different alternatives reflect different possible approaches to such balancing.

3.2.1. Action Alternatives for the MYs 2022-2026 Amendment

3.2.1.1. Alternative 1

The Alternative 1 begins with a MY 2022 set of target function parameters, with which 80 percent of the passenger car fleet complied in MY 2022, and 80 percent of light trucks complied in MY 2022. From there, Alternative 1 would increase CAFE stringency by 0.5 percent per year for MYs 2022-2026 for passenger cars and light trucks.

Table 3-8: Passenger Car CAFE Target Function Coefficients for Alternative 1 for the MYs 2022-2026 Amendment

	2022	2023	2024	2025	2026

a (mpg)	37.10	37.28	37.47	37.66	37.85
b (mpg)	31.62	31.78	31.94	32.10	32.26
c (gpm per s.f.)	0.00042463	0.00042251	0.00042041	0.00041832	0.00041624
d (gpm)	0.00869688	0.00865362	0.00861056	0.00856772	0.00852510

Table 3-9: Light Truck CAFE Target Function Coefficients for Alternative 1 for the MYs 2022-2026 Amendment

	2022	2023	2024	2025	2026
a (mpg)	33.96	34.12	34.30	34.47	34.64
b (mpg)	19.78	19.88	19.98	20.08	20.18
c (gpm per s.f.)	0.00065929	0.00065601	0.00065275	0.00064950	0.00064627
d (gpm)	0.00176047	0.00175171	0.00174300	0.00173432	0.00172570

Table 3-10: Alternative 1 – Minimum Domestic Passenger Car Standard (MPG) for the MYs 2022-2026 Amendment

2022	2023	2024	2025	2026
32.2	32.2	32.6	32.8	33.0

3.2.1.2. Alternative 2 – Preferred Alternative

The Preferred Alternative begins with a MY 2022 set of target function parameters, with which 75 percent of the passenger car fleet complied in MY 2022 and 70 percent of light trucks complied in MY 2022. From there, the Preferred Alternative would increase CAFE stringency by 0.5 percent per year for MYs 2022-2026 for passenger cars and light trucks. The MDPCS is calculated as the 92 percent of the average standard for an entire passenger call fleet for the given model year.

Table 3-11: Passenger Car CAFE Target Function Coefficients for Alternative 2 for the MYs 2022-2026 Amendment

	2022	2023	2024	2025	2026
a (mpg)	38.14	38.33	38.52	38.71	38.91
b (mpg)	32.51	32.67	32.83	33.00	33.16
c (gpm per s.f.)	0.00041302	0.00041097	0.00040892	0.00040689	0.00040487
d (gpm)	0.00845926	0.00841718	0.00837530	0.00833363	0.00829217

Table 3-12: Light Truck CAFE Target Function Coefficients for Alternative 2 for the MYs 2022-2026 Amendment

	2022	2023	2024	2025	2026
a (mpg)	34.89	35.06	35.24	35.41	35.59
b (mpg)	20.33	20.43	20.53	20.63	20.74
c (gpm per s.f.)	0.00064166	0.00063847	0.00063529	0.00063213	0.00062899
d (gpm)	0.00171340	0.00170487	0.00169639	0.00168795	0.00167955

Table 3-13: Alternative 2 – Minimum Domestic Passenger Car Standard (MPG) for the MYs 2022-2026 Amendment

2022	2023	2024	2025	2026

33.1	33.1	33.5	33.7	33.9

3.2.1.3. Alternative 3

Alternative 3 begins with a MY 2022 set of target function parameters, with which 70 percent of the passenger car fleet complied in MY 2022 and 50 percent of light trucks complied in MY 2022. From there, Alternative 3 would increase CAFE stringency by 0.5 percent per year for MYs 2022-2026 for passenger cars and light trucks.

Table 3-14: Passenger Car CAFE Target Function Coefficients for Alternative 3 for the MYs 2022-2026 Amendment

	2022	2023	2024	2025	2026
a (mpg)	39.60	39.80	40.00	40.20	40.40
b (mpg)	33.75	33.92	34.09	34.26	34.43
c (gpm per s.f.)	0.00039781	0.00039583	0.00039386	0.00039190	0.00038995
d (gpm)	0.00814761	0.00810707	0.00806674	0.00802660	0.00798667

Table 3-15: Light Truck CAFE Target Function Coefficients for Alternative 3 for the MYs 2022-2026 Amendment

	2022	2023	2024	2025	2026
a (mpg)	37.31	37.50	37.69	37.88	38.07
b (mpg)	21.74	21.85	21.96	22.07	22.18
c (gpm per s.f.)	0.00059995	0.00059697	0.00059400	0.00059104	0.00058810
d (gpm)	0.00160203	0.00159406	0.00158613	0.00157824	0.00157038

Table 3-16: Alternative 3 – Minimum Domestic Passenger Car Standard (MPG) for the MYs 2022-2026 Amendment

2022	2023	2024	2025	2026
34.4	34.4	34.8	35.0	35.2

3.2.2. Action Alternatives for the MYs 2027-2031 Amendment

3.2.2.1. Alternative 1

The Alternative 1 would increase CAFE stringency for passenger cars by 0.1 percent from MYs 2026-2027, by 0.3 percent from MYs 2027-2028, and by 0.25 percent year over year for MYs 2029-2031. Alternative 1 would increase CAFE stringency for light trucks by 0.8 percent from MYs 2026-2027, by 0.6 percent from MYs 2027-2028, and by 0.25 percent year over year for MYs 2029-2031.

Table 3-17: Passenger Car CAFE Target Function Coefficients for Alternative 1

	2027	2028	2029	2030	2031
a (mpg)	37.89	39.37	39.47	39.57	39.67
b (mpg)	32.29	29.48	29.56	29.63	29.71
c (gpm per s.f.)	0.00041574	0.00070967	0.00070790	0.00070613	0.00070436
d (gpm)	0.00851494	-0.00653427	-0.00651793	-0.00650164	-0.00648539

Table 3-18: Light Truck CAFE Target Function Coefficients for Alternative 1

	2027	2028	2029	2030	2031
a (mpg)	34.91	30.75	30.83	30.91	30.98
b (mpg)	20.34	25.34	25.41	25.47	25.53
c (gpm per s.f.)	0.00064119	0.00038562	0.00038465	0.00038369	0.00038273
d (gpm)	0.00171212	0.01246562	0.01243445	0.01240337	0.01237236

Graphs of the equations based on these are shown in Chapter 1.2.1 of the Draft TSD.

For this rulemaking, NHTSA has updated its analysis to estimate an offset of 0.7 percent, which will be applicable to the MDPCS for each action alternative in MYs 2027-2031. Under this alternative, the MDPCS would be as follows:

Table 3-19: Alternative 1 – Minimum Domestic Passenger Car Standard (MPG)

2027	2028	2029	2030	2031
33.0	33.1	33.2	33.2	33.3

3.2.2.2. Alternative 2 – Preferred Alternative

The Preferred Alternative would increase CAFE stringency for passenger cars by 0.35 percent from MYs 2026-2027, by 0.25 percent from MYs 2027-2028, and by 0.25 percent year over year for MYs 2029-2031. The Preferred Alternative would increase CAFE stringency for light trucks by 0.7 percent from MYs 2026-2027, by 0.25 percent from MYs 2027-2028, and by 0.25 percent per year for MYs 2029-2031.

Table 3-20: Passenger Car CAFE Target Function Coefficients for the Alternative 2

	2027	2028	2029	2030	2031
a (mpg)	39.04	40.57	40.67	40.78	40.88
b (mpg)	33.28	30.38	30.46	30.54	30.61
c (gpm per s.f.)	0.00040346	0.00068863	0.00068691	0.00068519	0.00068348
d (gpm)	0.00826345	-0.00634053	-0.00632468	-0.00630887	-0.00629310

Table 3-21: Light Truck CAFE Target Function Coefficients for the Alternative 2

	2027	2028	2029	2030	2031
a (mpg)	35.84	31.45	31.53	31.61	31.69
b (mpg)	20.88	25.92	25.99	26.05	26.12
c (gpm per s.f.)	0.00062460	0.00037701	0.00037607	0.00037513	0.00037419
d (gpm)	0.00166784	0.01218745	0.01215698	0.01212659	0.01209627

Graphs of the equations based on these coefficients shown in Figures IV-10 and IV-11 in Section III.B.2.i of the preamble.

For this rulemaking, NHTSA has updated its analysis to estimate the offset applied to the MDPCS, which is now calculated at 0.7 percent and is applied to each action alternative in MYs 2027-2031. Under this alternative, the MDPCS would be as follows:

Table 3-22: Alternative 2 – Minimum Domestic Passenger Car Standard (MPG)

2027	2028	2029	2030	2031
34.0	34.1	34.2	34.2	34.3

3.2.2.3. Alternative 3

Alternative 3 would increase CAFE stringency for passenger cars by 1.4 percent from MYs 2026-2027, by 1.5 percent from MYs 2027-2028, and by 1.0 percent year over year for MYs 2029-2031. Alternative 3 would increase CAFE stringency for light trucks by 0.4 percent from MYs 2026-2027, by 0.2 percent from MYs 2027-2028, and by 1.0 percent year over year for MYs 2029-2031.

Table 3-23: Passenger Car CAFE Target Function Coefficients for Alternative 3

	2027	2028	2029	2030	2031
a (mpg)	40.96	43.09	43.52	43.96	44.41
b (mpg)	34.91	32.27	32.59	32.92	33.26
c (gpm per s.f.)	0.00038460	0.00064843	0.00064195	0.00063553	0.00062917
d (gpm)	0.00787715	-0.00597040	-0.00591070	-0.00585159	-0.00579307

Table 3-24: Light Truck CAFE Target Function Coefficients for Alternative 3

	2027	2028	2029	2030	2031
a (mpg)	38.21	33.52	33.86	34.20	34.54
b (mpg)	22.26	27.62	27.90	28.18	28.47
c (gpm per s.f.)	0.00058580	0.00035380	0.00035026	0.00034676	0.00034329
d (gpm)	0.00156423	0.01143710	0.01132273	0.01120950	0.01109741

Graphs of the equations based on these coefficients are shown in Chapter 1.2.1 of the Draft TSD.

Under this alternative, the MDPCS would be as follows:

Table 3-25: Alternative 3 – Minimum Domestic Passenger Car Standard (MPG)

2027	2028	2029	2030	2031
35.7	36.2	36.6	36.9	37.3

4. Approach to Modeling CAFE Standards

CAFE Model Files Referenced in this Chapter

Below is a list of CAFE Model Files referenced in this chapter. See TSD Chapter 2.1.9 “Where to Find the Internal NHTSA Files” for a full list of files referenced in this document and their respective file locations.

- Market Data Input File

This chapter describes NHTSA’s approach to analyzing the wide range of effects of fuel economy standards. Over numerous prior rulemaking efforts, NHTSA has developed the CAFE Model to facilitate the different analyses required for CAFE rulemakings. NHTSA continues to refine the CAFE Model’s methodology to allow NHTSA to improve its consideration of the impacts of CAFE standards. By simulating a wide range of real world constraints and practices related to automotive engineering, planning, and production, such as common vehicle platforms, sharing of engines among different vehicle models, and timing of major vehicle redesigns, the CAFE Model is able to show realistic pathways manufacturers could follow over time in applying new technologies. This allows NHTSA to better assess the impacts of potential future standards. The CAFE Model has been designed to use inputs that provide an estimate of the fuel economy achieved for tens of thousands of different potential combinations of fuel-saving technologies, considering the technological heterogeneity of manufacturers’ current product offerings and the wide range of ways in which the many fuel-economy-improving technologies can be combined. Across the range of technology classes the analysis fleet encompasses, there are more than a million such estimates. While the CAFE Model does not require a specific approach to developing these inputs, the National Academy of Sciences has recommended and stakeholders have commented supporting that full-vehicle simulation provides the best balance between realism and practicality. Department of Energy (DOE)/ Argonne National Laboratory (Argonne) has spent several years developing, applying, and expanding means to use distributed computing to exercise its Autonomie full-vehicle modeling and simulation tool over the scale necessary for realistic analysis of CAFE standards. This scalability and related flexibility (in terms of expanding the set of technologies to be simulated) makes Autonomie well-suited for developing inputs to the CAFE Model.

In addition, DOE/Argonne’s Autonomie has a long history of development and widespread application by a wide range of users in government, academia, and industry. Many of these users apply Autonomie to inform funding and design decisions. These real world exercises have contributed significantly to aspects of Autonomie important to producing realistic estimates of fuel economy levels, such as estimation and consideration of performance, utility, and drivability metrics (e.g., towing capability, shift busyness, or frequency of engine on/off transitions). This increasing realism has raised confidence in the appropriateness of using Autonomie to make significant investment decisions. Notably, DOE uses Autonomie for analysis supporting budget priorities and plans for programs managed by its Vehicle Technologies Office.

Both Autonomie and the CAFE Model benefit from ongoing refinement (see the CAFE Model Documentation in Chapter 1 for an overview of refinements made to the CAFE Model and inputs over time). The combination of models in the most recent iteration produces a realistic characterization of the potential impacts of proposed new standards. Many stakeholders that have supported the agency’s reliance on the DOE/Argonne Autonomie tool and CAFE Model have noted not only technical reasons to use these models, but the efficiency, transparency, and ease with which outside parties can utilize models and replicate the agency’s analysis.

NHTSA’s analyses involve estimating how the application of various combinations of technologies could impact vehicles’ costs and fuel economy levels; estimating how vehicle manufacturers might respond to standards by adding fuel-saving technologies to new vehicles; estimating how changes in new vehicles might affect vehicle sales and operation; and estimating how the combination of these changes might influence national-scale energy consumption, emissions, and highway safety. The analysis of these components informs and supports NHTSA’s application of the statutory factors involved in determining “maximum feasible” fuel economy under EPCA, including, among others, economic practicability and the need of the United States to conserve energy. The CAFE Model plays a central role in NHTSA’s analysis supporting this proposed rule. In addition, the Draft EIS accompanying this proposed rule addresses the proposed rule's effect on various environmental measures, and the role that those changes have on the environment and human health.

In general, changes to the standards create streams of benefits and costs that accrue to vehicle producers when they build and sell vehicles, to owners when they purchase and use vehicles, and to the rest of society as they interact with a population of vehicles that has been influenced in some way by the standards. This chapter provides an overview of these pillars of the CAFE Model's structure. The purpose of this overview is to describe the Model's functions and how the Model simulates the effects of changes to fuel economy standards. The CAFE Model documentation accompanying this proposed rule provides a comprehensive and detailed description of the Model's functions, design, inputs, and outputs.[43]

The basic design of the CAFE Model is as follows: the system runs a compliance simulation, which estimates how vehicle manufacturers might respond to a given regulatory scenario, using inputs that define the range of their specific products; the projected efficacy and cost of technologies projected to be commercially available; projected fuel prices and consumer willingness to pay for fuel economy improvements; and the standards defining the regulatory scenario. A regulatory scenario involves specification of the form, or shape, of the standards (e.g., flat standards, or linear or logistic attribute-based standards), scope of regulatory classes, and stringency of the CAFE standards for each model year to be analyzed. Then, the system runs an effects calculation, which quantifies the manufacturers' response in terms of vehicle sales and retirements, fuel consumption, emissions, and economic externalities.

Manufacturer compliance simulation begins with a detailed, user-provided initial representation of the vehicle models offered for sale in a recent model year (MY 2024 for this proposed rule).[44] The compliance simulation then attempts to bring each manufacturer into compliance with the standards defined by the regulatory scenario. For example, a regulatory scenario may define CAFE standards that increase in stringency by a given percent per year for a given number of consecutive years.

The Model applies various technologies to different vehicle models in each manufacturer's product line to simulate how each manufacturer might make progress toward compliance with the specified standard. Subject to a variety of user-controlled constraints,[45] the Model applies technologies based on their relative cost effectiveness, as determined by several input assumptions regarding the cost and effectiveness of each technology, the cost of compliance, and the consumer's willingness to pay for avoided fuel expenses. For a given manufacturer, the compliance simulation algorithm applies technologies either until the manufacturer runs out of cost-effective technologies,[46] or the manufacturer either reaches compliance or exhausts all available technologies in an effort to do so. At this stage, the Model assigns an incurred technology cost and updated fuel economy to each vehicle model. This compliance simulation process is repeated for each model year included in the study period (through MY 2050 in this analysis).[47]

This point marks the Model's transition between compliance simulation and effects calculations. At the conclusion of the compliance simulation for a given regulatory scenario, the Model produces a representation of the corresponding registered light duty vehicle population in the United States. The CAFE Model then uses this fleet to generate estimates of the following (for each model year and calendar year included in the analysis): lifetime travel, fuel consumption, the magnitude of various economic externalities related to vehicular travel (e.g., congestion and noise), and energy consumption (e.g., the economic costs of short-term increases in petroleum prices, or damages associated with criteria pollutant emissions). The system then

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[43] The CAFE Model is available at https://www.nhtsa.gov/corporate-average-fuel-economy/cafe-compliance-and-effects-modeling-system, with documentation and all inputs and outputs supporting this final rule.
[44] For more detail on the compliance data used to construct the analysis fleet, see Draft TSD Chapter 2.2.1.1.
[45] When used to support NHTSA's analysis for standard setting, the compliance simulation is constrained based on statutory limitations on what NHTSA may consider when setting CAFE standards. When the CAFE Model is used to support the analysis in the EIS, these constraints are removed.
[46] Generally, the model considers a technology "cost effective" if it pays for itself in fuel savings within 36 months, a duration that reflects buyers' significant undervaluation of fuel savings relative to a simple actuarial projection of lifetime fuel savings (see Chapter 2.1.4). Depending on the settings applied, the model can continue to apply technologies that are *not* cost effective rather than choosing other compliance options; if it does so, it will apply those additional technologies in order of cost effectiveness.
[47] The extension through CY 2050 reflects a balance between completeness and uncertainty, as well as the need to capture the interactions of the new and used vehicle markets as the vehicles produced in the regulated model years are used, age, and retire. EIA's AEO 2025 also uses a modeling horizon that extends through CY 2050.

uses these estimates to measure the benefits and costs associated with each regulatory alternative (relative to the No-Action Alternative).

4.1. Representing Manufacturers' Potential Responses to Standards

To simulate how manufacturers may respond to the modeled regulatory scenarios, the CAFE Model requires information outlining the engineering characteristics and technology content attributable to each vehicle, platform, engine, and transmission produced by that manufacturer. This information provides the Model with an overall view of the initial state of the fleet, for each manufacturer regulated by the standards. The MY 2024 analysis fleet is contained in the Market Data Input File and includes information about each regulated manufacturer's:

- Vehicle models offered for sale—their current production volumes (for this rule, MY 2024) and MSRPs; fuel economy (as measured on the compliance test procedure); fuel-saving technology content (relative to the set of technologies summarized in Table 2-4 and Table 2-5 of the Draft TSD Chapter 2.2.1.3); footprint (necessary to compute the vehicle's fuel economy target under each regulatory alternative); curb weight, GVWR, and Gross Combined Weight Rating; as well as other attributes (drive type, assignment to technology class and regulatory class);
- Production constraints—product cadence of vehicle models (i.e., schedule of model redesigns and less significant "freshenings"); vehicle platform membership; degree of engine or transmission sharing (for each model variant) with other vehicles in the fleet; and
- Compliance constraints and flexibilities—manufacturers' perception of consumers' willingness to pay for fuel economy (assuming manufacturers add technologies that payback within 36 months); deployment of AC improvements and OC technologies for compliance purposes (only through MY 2027).

All of that information collectively provides the foundation on which the CAFE Model builds an assessment of how each manufacturer could comply with a given regulatory alternative. The regulatory alternatives, while applicable to all manufacturers in the analysis, affect individual manufacturers differently. Each manufacturer's actual CAFE compliance obligation represents the production-weighted harmonic mean of their vehicles' targets in each regulated fleet. The fuel economy targets are a function of the vehicles' footprints. This means that no individual vehicle has a "standard," merely a target, and each manufacturer is free to identify a compliance strategy that makes the most sense given its unique combination of vehicle models, consumers, and competitive position in the various market segments. Because the CAFE Model provides flexibility when defining a set of CAFE standards, each manufacturer's requirement is dynamically defined based on the specification of the standards for any simulation and the distribution of footprints within each fleet. The specific details of the MY 2024 analysis fleet are discussed in the Draft TSD Chapter 2.2 and preamble Section III.C.

4.2. Representing Consumer Responses to Standards

Because manufacturers apply technology to their vehicle offerings to comply with standards or in response to consumer choice in terms payback, the cost to supply vehicles will change. The agency assumes all costs related to compliance (the cost of technology) are passed through to buyers of new vehicles. The CAFE Model explicitly simulates these price effects on the new vehicle market. The Model uses a price elasticity to adjust aggregate new vehicle sales, relative to the No-Action Alternative. The price elasticity acts on an adjusted average price increase—the average price increase net of some portion of realized fuel savings (the first 36 months in this analysis) and any Federal incentives passed through to consumers. While the value of the elasticity is a user-defined input, this analysis assumes an elasticity equal to -0.4. The assumption is discussed in greater detail in the context of estimating the response of sales to higher prices and increased fuel economy, in Draft TSD Chapter 4.2.1 and preamble Section III.E.1. NHTSA has explored the sensitivity of its results to this assumption in PRIA Chapter **Error! Reference source not found.**.

This portion of the sales response only creates deviations from the No-Action Alternative vehicle sales forecast. The reference baseline sales forecast is a function of macroeconomic inputs and trends in historical sales. The passenger car/light truck composition of new vehicle sales in the light duty fleet is determined by the CAFE Model's fleet share module. Fleet share forecasts are determined by exogenous projections of vehicle fleet share.

The sales and fleet share modules work together to modify the total number of new vehicles, the share of passenger cars and light trucks, and consequently, the number of each given model sold by a given manufacturer in the No-Action Alternative. Changes to aggregated sales (either total sales or passenger car/light truck body styles) are distributed to individual manufacturers and vehicle models based on their observed shares in the MY 2024 fleet. The CAFE Model adjusts the fleet shares of passenger cars and light trucks in each regulatory alternative based on changes in their relative adjusted average price increases relative to the No-Action Alternative. Draft TSD Chapter 4.2.1 provides additional details on the CAFE Model's approach to sales and fleet share.

In addition to capturing the influence of changes to average new vehicle prices on total new vehicle sales, the CAFE Model accounts for expected changes to the used vehicle population as a consequence of those price changes (and differences in fuel consumption). In particular, the CAFE Model estimates the probability that used vehicles of a given age and body style remain in service each year. It uses this function to retire portions of older vehicle cohorts in a manner that is responsive to both macroeconomic conditions and simulated price changes in the new vehicle market that influence used vehicle transaction prices and residual value. To the extent that a given set of standards accelerates or decelerates the retirement (or scrappage) of vehicles, additional fuel consumption and social costs may accrue. The CAFE Model accounts for those costs and benefits, as well as tracking all the standard benefits and costs associated with the lifetimes of new vehicles produced under the rule. Draft TSD Chapter 4.2.2 contains more details about the CAFE Model's approach to vehicle scrappage.

Another critical element of the consumer response to the standards is the effect on demand for travel. When new vehicles become more efficient, the cost-per-mile of driving them decreases, which is assumed to spur additional demand for travel. This assumed behavior is often called the “rebound effect.” The rebound effect is incorporated into the vehicle miles traveled (VMT) analysis via a rebound elasticity (i.e., the percentage change in VMT demanded for a given percentage change in fuel economy).

When modeling regulatory alternatives for the light duty fleet, the CAFE Model uses official FHWA forecasts to define a constraint on “non-rebound” VMT that is held constant across regulatory alternatives, and implicitly includes any changes to both fuel prices over time and the average efficiency of the on-road fleet (as newer more efficient vehicles replace older ones over time). NHTSA's perspective is that the total demand for VMT should not vary excessively across alternatives; the basic travel needs for an average household are unlikely to be influenced directly by the stringency of the CAFE standards (i.e., by the impact of CAFE standards on new vehicle prices and fuel economy levels), as the daily need for vehicle use will remain the same. That said, it is reasonable to assume that fleets with differing age distributions and inherent costs of operation will have slightly different annual VMT (even without considering VMT associated with rebound miles); however, the difference could conceivably be small. Based on the structure of the CAFE Model, the combined effect of the sales and scrappage responses can create small percentage differences in total VMT across the range of regulatory alternatives if steps are not taken to constrain VMT.

This methodology constrains the Model so that the only estimated difference in VMT among the alternatives are a direct consequence of the degree of fuel economy improvement relative to MY 2024 and the magnitude of the rebound effect assumption. However, this also implies that, as fleet composition varies by alternative (the most aggressive alternatives may also produce on-road fleets with higher average ages), some of the total VMT demanded is redistributed from the new vehicle fleet to the newer vehicles in the used fleet, and this redistribution creates additional costs and benefits that are associated with the regulatory alternative.

4.3. Representing the Physical and Environmental Effects of Standards

The CAFE Model includes a complete representation of the registered vehicle population in each calendar year, starting with an aggregated version of the most recent available data about the registered vehicle population for the first year of the simulation. This national registered fleet is used to calculate both annual and lifetime fuel consumption (by fuel type), VMT, pollutant emissions, and health impacts under each regulatory alternative. For the current analysis, MY 2024 is the first model year of the included vehicle fleet; therefore, the registered vehicle population enters the Model as it appeared at the end of CY 2023.

For the light duty fleet, the initial vehicle population is stratified by age (or model year cohort) and body style (cars, vans and sport utility vehicles [SUVs], and pickup trucks). Once the simulation begins, new vehicles are added to the population from the new vehicle market and age throughout their lives during the simulation, with some fraction of them being retired (or scrapped) in each year along the way. For example, in CY 2025, the new vehicles (age 0) are MY 2025 vehicles (added by the CAFE Model simulation and represented at the same level of detail used to simulate compliance). The age 1 vehicles are MY 2024 vehicles (added by the CAFE Model simulation), and the age 2 vehicles are MY 2023 vehicles (inherited from the registered vehicle population and carried through the analysis with less granularity).

The product of on-road fuel economy and VMT determines fuel consumption, by fuel type, of each vehicle and cohort in the analysis (vehicles produced after MY 2023 are simulated at the model level and all older vehicles as body-style/age cohorts). All the physical and environmental impacts in the analysis are the consequence of either fuel consumption or VMT. The CAFE Model accumulates these totals on an annual (calendar year) basis but can also compute the lifetime totals of any physical quantity by model year cohort. Importantly, the calendar year totals for quantities like fuel consumed or miles traveled include both the new vehicle fleet (produced after MY 2023) and the legacy fleet (produced before MY 2024). Some concessions are necessary to represent these model years in the CAFE Model. For example, the CAFE Model only accounts for vehicles until age 40, while the actual on-road fleet has a non-trivial number of vehicles older than that. Even with these concessions, it is reasonable to compare calendar year totals of physical quantities to observed values in earlier years and some projections from other sources.

Rather than rely on the compliance values of fuel economy for either legacy vehicles or vehicles that go through the full compliance simulation (based on 2-cycle laboratory testing), the Model adjusts the fuel economy values to better represent fuel economy under real world operation. This is done by accounting for an “on-road gap.” While the Model currently allows the user to specify an on-road gap that varies by fuel type (gasoline, E85, diesel, electricity, hydrogen, and compressed natural gas (CNG)), it does not vary over time, by vehicle age, or by technology combination. As discussed below, this analysis uses input values that range from 24 to 29 percent, depending on the fuel type. It is possible that the “gap” between fuel economy as measured for CAFE compliance purposes and fuel economy under real world operation has changed over time. It is also possible that fuel economy degrades over time as a vehicle ages, or that specific combinations of fuel-saving technologies have a larger (or smaller) discrepancy between 2-cycle testing and real world fuel economy than others.

In addition to the above effects, the Model also calculates emissions effects and projected economic consequences of changes in fuel consumption. Emissions are identified and tracked separately as “downstream” emissions (i.e., a function of vehicle use) and “upstream” emissions (i.e., a function of fuel use). To calculate downstream emissions for most pollutants associated with a given alternative, the CAFE Model uses the entire on-road fleet, calculated VMT (discussed above), and per-mile emissions factors (which are an input to the CAFE Model, specified by model year and age). Downstream CO_2 emissions quantities are derived from the assumed carbon content (an input to the CAFE Model, specified by fuel type) and the estimated quantity of fuel consumed. Total upstream emissions estimates depend on the fuel type. Gasoline and diesel emissions factors account for multiple levels of the fuel cycle, including fuel extraction, transportation, refining, and distribution. Draft TSD Chapter 5 contains additional details about emissions inputs for the analysis.

Because the Model produces an estimate of the aggregate number of gallons of fuel sold in each calendar year, it is possible to calculate both the total expenditures on fuel and the total contribution to the Highway Trust Fund (HTF) that result from that fuel consumption. The Federal fuel excise tax is levied on every gallon of gasoline and diesel sold in the United States, with diesel facing a higher per-gallon tax rate. The Model uses a national perspective, where the state taxes in the input files represent an estimated average fuel tax across all United States. While the Model produces an estimate of HTF revenue changes, it is not possible to use the CAFE Model to reasonably estimate potential losses to state fuel tax revenue from increasing the fuel economy of new vehicles. Additionally, states and the Federal Government have occasionally raised motor fuel tax rates to partially compensate for revenue losses due to inflation and increased fuel economy.[48] However, such actions have been sporadic and unpredictable, and so the agency assumes continuation of the present fuel tax rates.

4.3.1. Compliance and Real World Fuel Economy "Gap"

In accordance with EPCA, compliance with NHTSA's CAFE standards is determined using testing and calculation procedures prescribed by EPA. Under EPA's regulations, compliance is based on two separate test cycles, the "city" and "highway" cycles.[49] These are commonly referred to as the 2-cycle tests. In 2008, EPA introduced three additional test cycles to bring values for the consumer label in line with real world fuel economy consumers experience in the real world. This is known as 5-cycle testing.

Generally, the 5-cycle testing values have proven to be a good approximation of what car owners will experience during vehicle operation, significantly more representative than the 2-cycle test values.

The CAFE regulatory analysis utilizes the 2-cycle fuel economy values for evaluating the manufacturers' compliance positions. For calculating the modeling effects, the CAFE analysis relies on the "on-road" fuel economy values to model real world effects more representatively.

The agency applies a percent difference between the 2-cycle test and 5-cycle test to represent the gap in compliance fuel economy and real world fuel economy.[50,51] This percent difference, or "gap," is calculated as shown in Equation 4-1. For the effects calculation in the Model, the on-road fuel economy values are obtained by applying the FE gap percentages to the FE calculated by the Model for the regulatory scenario.

Equation 4-1: Percent Difference Between 2-Cycle and 5-Cycle Tests

$$\frac{\textit{2cycleFE-5cycleFE}}{\textit{2cycleFE}} \textit{*100=“fuel economy” gap (\%)}$$

Table 4-1 below shows a summary of the inputs used for the fuel economy gap for fuel types.[52] The underlying data are EPA test data.[53] The agency analyzes the fuel economy gap using recent compliance test data. For this gap analysis, compliance test data from vehicle MYs 2022-2024 are used. The results of the gap analysis substantiate the values in Table 4-1 below. The data shown are calculated average fleetwide values. A specific vehicle's fuel economy gap could be lower or higher based on differing factors for each vehicle. Draft TSD Chapter 2.1.4 contains additional information related to the Parameters Input File.

Table 4-1: 2-Cycle to 5-Cycle "Gap" Used for This Analysis, by Fuel Type

	Cars	Vans/SUVs/LTs
Gasoline	24%	24%
Ethanol-85	24%	24%
Diesel	24%	24%
Electricity	29%	29%
Hydrogen	29%	29%
CNG	24%	24%

[48] Greene, D. L., What Is Greener Than a VMT Tax? The Case for an Indexed Energy User Fee to Finance U.S. Surface Transportation, *Transportation Research Part D: Transport and Environment*, Vol. 16(6): pp. 451 – 58 (2011), available at: https://doi.org/10.1016/j.trd.2011.05.003 (accessed: Sept. 10, 2025).
[49] 49 U.S.C. 32904(c) and 40 CFR 600.510-12.
[50] For more details see the CAFE Model Documentation (Chapter 3, Section 3, p. 151 and Appendix A.3.1 Table 35, p. 219).
[51] National Research Council, Cost, Effectiveness, and Deployment of Fuel Economy Technologies for Light-Duty Vehicles, pp. 347 – 50 (2015), available at: https://doi.org/10.17226/21744 (accessed: Sept. 10, 2025).
[52] This input is specified in the Parameters Input File ("Economic Values" Tab).
[53] EPA, Download Fuel Economy Data, available at: https://www.fueleconomy.gov/feg/download.shtml (accessed: Sept. 10, 2025).

4.4. Costs and Benefits to Producers, Consumers, and Society

In simulating manufacturer compliance with regulatory alternatives and the response by consumers, the CAFE Model tracks and estimates several consequences that generate social costs and benefits. The most obvious cost associated with the CAFE program is the cost of any additional fuel-saving technology added to new vehicles as a result of the alternatives considered in the analysis. For each technology that the Model adds to a given vehicle, it accumulates cost. As the Model carries forward technologies already applied to future model years, it similarly adjusts the costs of those technologies based on their individual learning rates.[54]

The other costs that the CAFE Model tracks for manufacturers, if applicable, are civil penalties resulting from non-compliance with the standards. For this analysis, because the penalty rate is $0, the regulatory costs do not include any costs associated with penalties.[55]

The costs and benefits of each alternative are defined relative to the No-Action Alternative. The CAFE Model estimates the amount of money spent on fuel in the No-Action Alternative, then estimates the amount spent on fuel in the alternatives in absolute terms, as well as relative to the No-Action Alternative.

The CAFE Model also enforces a constraint on benefit-cost accounting applicable to all alternatives. If the CAFE Model did not impose the constraint that MYs 2025-2026 be identical across alternatives (and identical to the No-Action Alternative for those model years), the multi-year planning algorithm would reach back to as early as MY 2025 to apply additional technology under more stringent alternatives. In this analysis, the agency assumes that manufacturers are unable to modify product offerings during MY 2024 under *any* alternative (No-Action or otherwise), or during MYs 2025-2026 (which have been fully or partially planned) under the Action Alternatives (beyond the level by which the manufacturers' fleet was improved to comply with the standards posed by No-Action Alternative). The technology outcomes of the compliance simulation in MYs 2024-2026 under the No-Action Alternative are, therefore, forced in those years for the other alternatives as well. As a result, the CAFE Model simulates no incremental costs or benefits for those years across alternatives.

The list of social costs and benefits is presented in Table 4-2, as well as the population of vehicles that determines the size of the factor (i.e., new vehicles or all registered vehicles) and the mechanism that determines the size of the effect (i.e., vehicle use in terms of miles driven, the amount of fuel consumed, or the number of vehicles produced).

Table 4-2: Social Costs and Benefits in the CAFE Model

Cost/Benefit	Population	Mechanism
Technology cost	New vehicles	Production volume
Consumer surplus	New vehicles	Production volume
Implicit opportunity cost	New Vehicles	Production volume
Benefit of additional mobility	New vehicles	Vehicle use
Benefit of less frequent refueling	New vehicles	Fuel consumption
Retail fuel savings	All vehicles	Fuel consumption
Fuel tax revenue	All vehicles	Fuel consumption
Energy security cost	All vehicles	Fuel consumption
Congestion and noise costs	All vehicles	Vehicle use
Non-fatal injuries	All vehicles	Vehicle use

[54] For more details on learning rates, see Draft TSD Chapter 2.4.3.
[55] On July 4, 2025, President Trump signed OB3 (Pub. L. 119-21), which revised 49 U.S.C. 32912 and reduced the civil penalty to $0 for each 0.1 of a mile a gallon by which the applicable fuel economy standard exceeds the manufacturer's average fuel economy. NHTSA has implemented this $0 civil penalty rate value in its analysis for all model years considered in the NPRM analysis.

Fatalities	All vehicles	Vehicle use
Criteria pollutant damages (NO_X, SO_X, PM)	All vehicles	Vehicle use, Fuel consumption
Non-criteria emissions damages (CO_2, CH_4, N_2O)	All vehicles	CO_2: Fuel consumption CH_4, N_2O: Vehicle use

4.5. Representing the Safety Effects of Standards

In the context of the CAFE Modeling framework, there are three avenues by which adjusting standards affects fleetwide safety: fleet size and composition, rebound-effect driving, and changes in vehicle mass. The first effect arises from changes in the price of new vehicles as manufacturers attempt to recover their incremental costs for complying with higher standards or reduce costs in the case of less stringent standards, which can alter total sales of new vehicles, the shares of passenger automobiles and non-passenger automobiles in total light duty vehicles sales, and retirement rates for used vehicles. Increased prices for new vehicles reduce their sales and slow the retirement of used models, and these two effects combine to slow the rate of fleet turnover. In turn, this causes a redistribution of some VMT from newer to older vehicles. Conversely, decreased prices for new vehicles increase the rate of fleet turnover, and shift VMT from older to newer vehicles. In the light duty market, it may shift sales and VMT between the passenger automobile fleet and the non-passenger automobile fleet.

Because the safety of new vehicles has gradually improved over time, redistributing VMT between newer and older vehicles impacts the overall safety of the entire vehicle fleet, affecting fatalities and injuries very slightly. The agency measures this effect by projecting differential fatality and injury rates for vehicles of different vintages (i.e., model years) and ages during future calendar years, and applying these rates to estimates of the redistribution of total VMT by model year and age that results from the changing sales of new models and retirement of older vehicles.

Second, when drivers choose to drive more as their cost-per-mile of driving decreases, and the VMT of new vehicles increases accordingly (i.e., the rebound effect), increasing the stringency of standards exposes their drivers and passengers as well as other road users to increased risks of being involved in crashes. Although vehicles that are produced during each successive model year are anticipated to be safer than their predecessors, their increased use results in slightly more crashes, and slightly larger numbers of fatalities and injuries. The agency measures this effect as the product of the change in driving in each future vintage of vehicles over their lifetimes, and the per-mile risks that roadway users will suffer fatal and non-fatal injuries in crashes, which decline gradually over future model years. Because this additional driving is a choice made by individuals who are generally cognizant of the injury and fatality risks it involves, the agency assumes that drivers internalize 90 percent of the increased safety risk and thus must experience an offsetting benefit of this magnitude. In the case of decreased stringency of standards and the absence of the rebound effect, the reduced VMT of new vehicles will result in slightly fewer fatalities and injuries, and the effect is calculated in the same manner as described above.

Finally, manufacturers may adjust the mass of some of their vehicle models as a strategy to comply with changing stringency of fuel economy standards. Reducing vehicle mass can sometimes offer a low-cost strategy to improve vehicle fuel economy. Depending on how the initial weight of those models compares to other vehicles in the fleet and how much manufacturers elect to change it, this change can modify the risks that occupants of these vehicles—and occupants of vehicles and non-motorists who would be involved in collisions with these vehicles—will be killed or injured if these vehicles become involved in crashes. The agency estimates this effect as the change in the risks that occupants of vehicles whose mass is adjusted and occupants of vehicles and non-motorists who would be involved in collisions with these vehicles will be injured or killed in crashes, multiplied by the number of miles they are driven each year over their expected lifetimes.

These three effects occur simultaneously and interactively within the simulation. Each vehicle model produced in a future model year has a base fatality rate that changes as it ages and accumulates mileage, but that rate can be modified by changes in its mass. At the same time, the vehicle's base fatality rate changes if its manufacturer elects to improve its fuel economy, and the vehicle can then be driven more (or fewer) miles over its lifetime. Finally, changes in new vehicle prices affect probability of retirement for used vehicles, and thus their expected use as they age. The rebound and sales/scrappage effects are identified outside of statistical models and therefore do not have estimated confidence bounds (in turn, neither do the aggregated safety effects). The estimated effects associated with changes in mass are identified based on a statistical model, but the component estimates are not statistically significant at the 95-percent confidence level. Draft TSD Chapter 7 provides a detailed discussion of how the Model measures safety outcomes.

5. Economic Impact of Fuel Economy Standards

This chapter describes NHTSA's approach for measuring the economic costs and benefits likely to result from establishing CAFE standards for future model years. In this chapter, NHTSA distinguishes the impacts of standards on private actors, such as vehicle manufacturers and buyers, from their broader impacts on the U.S. economy and public; describes the agency's perspective for measuring benefits and costs; discusses procedures for comparing impacts that occur when new vehicles are produced and sold to impacts that occur from vehicles' subsequent use; and illustrates how the agency summarizes and reports benefits and costs. Chapter 8 of this PRIA presents the agency's central empirical estimates of costs and benefits projected to result from the alternative standards considered in this proposal, while PRIA Chapter 9 describes those results' sensitivity to variation in the assumptions and parameters used to develop the agency's central estimates.

As OMB Circular A-4 states, benefits and costs reported in regulatory analyses should be defined and measured consistent with economic theory and should reflect how regulatory alternatives are anticipated to change the behavior of producers and consumers from a reference or baseline scenario. The following sections illustrate how NHTSA's measures of benefits and costs from changing CAFE standards are derived from economic analysis of markets for new and used vehicles, vehicle owners' decisions about how much to drive, and how U.S. production and imports of petroleum and gasoline are likely to respond to changes in fuel consumption that result from requiring manufacturers to provide alternate levels of fuel economy. As this discussion shows, CAFE standards are likely to alter the behavior of vehicle manufacturers, buyers and users of new vehicle models, owners of used vehicles, and suppliers of petroleum and refined fuel.

5.1. Overview of Effects of Changing Fuel Economy Standards

Figure 5-1 provides an overview of the inputs used in NHTSA's analysis of CAFE standards, traces the influence of fuel economy standards on the behavior of producers and consumers of vehicles and fuel, and highlights the resulting economic benefits and costs of standards. As the figure shows, vehicle manufacturers respond to changes in required fuel economy by extending or curtailing in the case of reductions in the stringency of fuel economy standards, their application of currently available technology to additional models in their product lineups. Vehicle manufacturers also respond to changes in standards by deciding whether to employ newly available technologies to improve their models' fuel economy. Both actions affect manufacturers' costs to produce new cars and light trucks, and changes in costs ultimately will be reflected in higher or lower selling prices for new models.

The agency's analysis assumes that manufacturers will comply with standards exclusively by changing their use of advanced technology and vehicle designs that affect vehicles' fuel efficiency, while holding vehicles' other key attributes, such as acceleration, towing and hauling capacity, and passenger- and cargo-carrying capacity, unchanged.[56] NHTSA's estimates of manufacturers' direct costs to comply with fuel economy standards include only those for the technology necessary to meet fuel economy standards while maintaining those other attributes at current levels. In practice, manufacturers may postpone or forgo planned improvements in these other attributes when higher standards require them to focus on increasing fuel economy or accelerate improvements in other features buyers value when lowering standards enables them to do so.

[56] Some technologies that manufacturers employ to improve fuel economy may produce incidental enhancements or sacrifices in other vehicle attributes, but the agency does not attempt to estimate these or any resulting changes in vehicles' value.

Figure 5-1: Overview of NHTSA's Analysis of Changes in Fuel Economy Standards

Inputs		Analysis		Outputs
• Technology and costs to meet fuel economy standards • Economic assumptions (e.g., future fuel prices) • Sales, fuel economy, and use of future model years under current standards • Number, retirement rates, fuel economy, and use of vehicles currently in operation	→	• Changes in prices, fuel economy, and other attributes of new vehicles • Changes in sales and use of new vehicles • Changes in retirement rates and use of previously produced vehicles by model year and age	→	• Vehicle fuel consumption and fuel costs by model year and age • Safety of vehicle travel • Externalities from refining and using fuel • Energy security costs from consuming and importing petroleum • Fuel tax revenue

NHTSA's analysis makes the simplifying assumption that manufacturers will raise or lower prices only as necessary to recover their additional costs for meeting higher standards (or as permitted by reductions in costs when standards are relaxed). The agency does not model pricing strategies where manufacturers attempt to recover their costs to improve some models' fuel economy by raising prices for others—in effect, "cross-subsidizing" those improvements—although the agency is aware that such practices are very common. Where tax credits or other subsidies are offered to manufacturers or buyers, the agency's analysis of costs and benefits from setting standards clearly identifies the assumptions it makes about how those will ultimately affect production costs and the fraction of changes in those costs that will be passed on to buyers in the form of higher or lower prices.[57]

When NHTSA reduces the stringency of standards, producers may decide to improve other features of their models that buyers find more attractive than fuel economy, or to reduce prices, to compare for increased sales. If standards are increased, manufacturers may postpone or forgo improvements to their models' other attributes as part of their efforts to achieve higher fuel economy; though this strategy would make their products less appealing to potential buyers, it would help to manage costs for meeting CAFE standards and lead to smaller increases in vehicle prices and losses in sales relative to the reference baseline. In the case where standards rise, price increases alone will not represent the full cost to consumers of meeting higher standards, as the vehicles they purchase will provide less utility and lower value.

The combination of changes in some models' fuel economy and prices is likely to affect their sales, but the size of the market response (and possibly even its direction) depends on whether potential buyers value savings in fuel costs offered by models with higher fuel economy more than their higher purchase prices. As discussed previously in Chapter 2 of this PRIA, NHTSA assumes that typical buyers value future savings in fuel costs from purchasing models offering improved fuel economy over only the first 36 months of those vehicles' lifetimes. The agency assumes that manufacturers will voluntarily apply any technologies that offer fuel savings sufficient to repay their initial costs within this 36-month period in each regulatory alternative and that manufacturers would employ additional technologies that require longer than 36 months to repay their initial costs via fuel savings only if compelled to do so by CAFE standards.

Where improvements to fuel economy are unprofitable and are no longer required because the stringency of CAFE standards has been reduced, the Model assumes that manufacturers will reduce the amount of technology they use to improve fuel economy and lower prices, resulting in increased sales of new cars and light trucks. Because CAFE standards compel manufacturers to use additional technology only to increase fuel economy from levels the market demands, reducing standards allows manufacturers to sell vehicles offering combinations of prices and features more closely in line with buyers' preferences. As a result, sales will increase. Conversely, where standards are increased, adding technology to meet higher standards will provide purchasers savings in fuel costs and make buyers willing to pay more to purchase them; however, manufacturers will presumably raise those models' selling prices to recover their higher costs. Because the

[57] NHTSA's analysis reflects the changes to tax credits in OB3.

resulting price increases will exceed buyers' willingness to pay for the incremental fuel savings,[58] the agency projects that total sales of new models will decline when it raises standards, and that the size of this decline will grow as it adopts more stringent standards.[59]

The response of new vehicle sales also will be influenced by how the combination of price changes and fuel economy changes affect potential buyers' choices between new and used models because acquiring or keeping a used vehicle can often substitute for buying a new one. Where NHTSA reduces the stringency of CAFE standards, lower prices for new vehicles will persuade more owners to sell or retire their used cars and replace them with safer new models, as described in Chapter 7 of this analysis. The decline in demand for used models will lower their market value and increase the number that are retired rather than being kept in use. In effect, some trips that would have been made in older vehicles under the baseline alternative will instead be made in new vehicles, raising the overall share of travel done in newer, safer models.

Conversely, if new vehicle prices increase in response to raised CAFE standards, some would-be new vehicle buyers are likely to purchase used models instead, while others may simply decide to retain their used vehicles longer; these responses will increase demand for used vehicles, which are older, more polluting, and less safe than their new counterparts. Higher demand will in turn increase the market value of used cars and light trucks because their supply is limited (although it is not fixed, which is discussed in detail in Chapter 7 of this PRIA, as well as in Draft TSD Chapter 4), so some vehicles that would otherwise have been retired will instead be maintained in working condition and driven longer. The combination of reduced sales of new vehicles and slower retirement of used ones will result in a larger share of total driving taking place in used, less safe cars and light trucks than if prevailing standards had remained in effect.[60]

As Figure 5-1 also shows, these responses will generate various other economic outcomes. Because new vehicles have become progressively safer over time, there continues to be a strong association between vehicles' ages, their involvement in crashes, and injuries their occupants sustain. Therefore, shifting travel from older to newer vehicles by reducing CAFE standards is likely to improve the safety of drivers and their passengers. The opposite occurs when NHTSA increases standards, and the resulting shift of some trips to older vehicles makes travel less safe overall. Improving new vehicles' fuel economy by raising standards reduces fuel costs and prompts owners to increase the number of miles they drive—via the fuel economy "rebound effect"—and this additional driving will partly offset the expected fuel savings. New vehicles featuring higher fuel economy will also have extended driving ranges and require less frequent refueling, thus saving their drivers and passengers time. These effects will be reversed if NHTSA reduces the stringency of CAFE standards from their baseline levels, as proposed in this NPRM.

Changing CAFE standards from their level under the baseline alternative will affect the volume of fuel distributed and consumed within the United States, which will also affect emissions of air pollutants and their consequences for public health. Changing the volume of fuel refined domestically or imported to the United States will also affect other consequences of petroleum consumption and imports, particularly the impact of rapid changes in fuel prices.

5.2. Measuring Benefits and Costs from CAFE Standards

NHTSA's analysis measures the economic benefits and costs from setting CAFE standards by the combined changes in consumers' and producers' welfare in all the markets the standards ultimately affect, plus any accompanying changes in externalities generated by producing and consuming fuel. The agency's assessment of alternative standards focuses on benefits and costs arising in those markets likely to be most directly affected, which include those for new automobiles, used vehicles, transportation fuels, and crude petroleum. Raising or lowering CAFE standards directly affects the market for new vehicles, and the consequences for the fuel economy, prices, and sales of new vehicles in turn generate various indirect impacts, including effects on new vehicles' use; the number of used vehicles in service and how much they

[58] See Chapter 2.1.4 for a discussion of why buyers may undervalue fuel savings.
[59] The clearest evidence that a decline in sales represents the most likely response is that if manufacturers could increase sales and profits by improving some models' efficiency and raising prices to recover their added costs, they would presumably do so even in the absence of higher standards.
[60] At the same time, the resulting increases in prices for *both* new and used vehicles will raise their owners' depreciation-related costs for driving, which would be expected to reduce total travel slightly and offset some fraction of increased driving that occurs because of the fuel economy rebound effect.

are driven; production and consumption of gasoline and other transportation fuels; and U.S. production, imports, and refining of petroleum.[61]

Throughout its analysis, NHTSA makes various assumptions to simplify the measurement of these benefits and costs, one of which is that changes in demand for transportation fuels caused by changes to CAFE standards are likely to be small enough not to affect their long run equilibrium prices.[62] The agency's analysis also assumes that the magnitude of externalities varies proportionally with changes in production or consumption activity that generates them. In other words, the value of externalities per unit of activity (e.g., per mile driven or per gallon of fuel consumed) is assumed to be unaffected by changes in production or consumption levels. NHTSA acknowledges that these assumptions simplify real world conditions, but the agency believes any effect on its estimates of benefits or costs from changing CAFE standards is likely to be modest.

5.2.1. Private Versus "External" Benefits and Costs

Throughout its analysis, the agency is careful to distinguish between private costs and benefits from raising or lowering CAFE standards experienced by vehicle manufacturers, households, and businesses that purchase and use vehicles, or fuel suppliers, and those likely to fall more broadly on the public or the U.S. economy. This distinction highlights that private households and businesses would experience the largest shares of benefits and costs that result from changing CAFE standards, while the external benefits and costs are likely to be smaller, even if more widely distributed.

5.3. NHTSA's Perspective for Measuring Benefits and Costs

This analysis relies on many economic assumptions and forecasts, and while these do not differ between the reference baseline scenario and the various regulatory alternatives considered, these inputs nevertheless contribute to the estimated benefits and costs of each regulatory alternative. Forecasts of overall U.S. economic activity, personal income, and other macroeconomic variables, which affect the projections of new vehicle sales and retirement rates of used vehicles, are taken from S&P Global Insight's March 2025 Macroeconomic Outlook and the Annual Energy Outlook 2025 (AEO 2025) of the U.S. Energy Information Administration (EIA).[63] AEO 2025 is also the source used for projections of U.S. fuel prices, global petroleum supply and prices, and U.S. imports of crude petroleum and refined fuel used throughout this analysis.[64] Finally, the agency relies on DOT guidance for valuing travel time when assessing the impacts of more or less frequent refueling, as well as for updating the estimates of vehicles' contributions to increased congestion costs originally reported in FHWA's 1997 Highway Cost Allocation Study.[65]

To assess the costs and benefits of this proposal, NHTSA first simulates the number of new vehicles produced during MYs 2024-2050, as well as the number, usage, and total fuel consumption by all petroleum-fueled light duty vehicles in use during CYs 2024-2089 (the last year when any vehicles produced during MY 2050 would be expected to remain in use). In this analysis, the agency assumes that CAFE standards for future model years would remain at the levels it is proposing to establish for MY 2031 (the last model year covered by this proposal) through MY 2050.[66] Although this proposed rule does not establish standards for

[61] Some gasoline consumed in the United States is imported in already-refined form, rather than refined domestically.
[62] While acknowledging that this assumption may simplify real world production conditions, NHTSA believes it is likely to have little effect on its estimates of benefits and costs from the regulatory action. This is because the *sum* of changes in consumer and producer surplus in each affected market is likely to vary relatively little under alternative assumptions about the extent to which supply is inelastic and prices change because of changes in demand of the magnitude likely to result from imposing higher CAFE standards. As Figure 7-9 in Chapter 7 of this PRIA demonstrates (using the case of the used vehicle market), assuming price-elastic supply means that prices will decline slightly in response to reduced demand. As that figure also suggests, the resulting gain in consumer surplus will be slightly more than offset by losses in producer surplus to suppliers, so the net change in welfare will be far smaller that either the impact on consumers or suppliers. This same result will prevail in the market for fuel, and the net effect on economic welfare will only be changed modestly in response to varying assumptions about the exact value of the price elasticity of fuel supply.
[63] EIA, Annual Energy Outlook 2025, Alternative Transportation Case Table 20, Last revised: 2025, available at: https://www.eia.gov/outlooks/aeo/tables_side_xls.php (accessed: Sept. 10, 2025).
[64] EIA, Annual Energy Outlook 2025, Alternative Transportation Case Tables 11 and 12, Last revised: 2025, available at: https://www.eia.gov/outlooks/aeo/tables_side_xls.php (accessed: Sept. 10, 2025).
[65] DOT, Benefit-Cost Analysis Guidance for Discretionary Grant Programs, DOT: Washington, DC (2025), available at: https://www.transportation.gov/sites/dot.gov/files/2025-05/Benefit%20Cost%20Analysis%20Guidance%202025%20Update%20II%20%28Final%29.pdf (accessed: Sept. 10, 2025).
[66] Including future model years through MY 2050 in the analysis is necessary to estimate benefits and costs of establishing standards for all vehicles that will be produced during the period used for this regulatory analysis, which extends through CY 2050.

those later model years, NHTSA attributes both costs and benefits from doing so to this rule, because the agency views it as establishing a precedent for future standards.

This PRIA measures and reports benefits and costs from revising fuel economy standards from two different perspectives. First, the agency's "model year" perspective focuses on benefits and costs of establishing alternative CAFE standards for MYs 2027-2031[67] and measures these over each separate model year's entire lifetime.[68] Second, the agency's "calendar year" perspective sums the costs and benefits of changing fuel economy standards for specific model years on the composition and use of the *entire* light duty vehicle fleet during each future calendar year and typically aggregates these impacts over a series of calendar years (in this analysis, CYs 2024-2050). This perspective includes the effects of the proposed standards on the number, use, and fuel consumption of vehicles from all model years that remain in use during future calendar years, including vehicles produced before the analysis period begins.

The agency's model year and calendar year accounting approaches each offers different strengths and limitations. The primary advantage of model year accounting is that it allows NHTSA to focus on the costs and benefits of changing CAFE standards that apply to model years for which it is currently proposing standards. However, the model year perspective omits some effects of setting standards for a single model year on the use and fuel consumption of vehicles produced during other model years that make up the remainder of the fleet.[69] In contrast, the agency's calendar year perspective also includes the effects of establishing standards for a limited range of near-term model years on the number, usage, and fuel consumption of vehicles produced during both earlier and later model years.

For example, amending CAFE standards for MYs 2027-2031 will affect those standards assumed to apply during subsequent model years because the agency's calendar year analysis assumes that standards would remain fixed at the levels each regulatory alternative establishes for 2031 (the last model year covered by this final rule). The lower prices for new vehicles produced and sold during MY 2032 and beyond that result from lower fuel economy standards will increase their sales and thus decrease the lifetime use of vehicles produced during the earlier model years for which this rule proposes new CAFE standards (NHTSA expects this effect to be extremely small). Although the agency's model year accounting would capture the indirect effects of lower standards for MY 2031 on those earlier model years (MYs 2027-2030), it would not capture the other benefits and costs from setting lower standards for MY 2032 and beyond for model years that predate the regulatory timeframe, such as MYs 2025-2026.

While the calendar year approach avoids potentially inconsistent accounting of benefits and costs, it has other limitations. For one, calendar year accounting misses a significant portion of the changes in lifetime fuel consumption and health impacts from setting fuel economy standards assumed to apply to vehicles produced later in the analysis period because it omits any of those impacts that occur after the analysis period ends. As an extreme example, only the first year of fuel savings for MY 2050 vehicles will be included because the agency's calendar year analysis ends in that year.[70]

Second, calendar year accounting captures benefits and costs from CAFE standards assumed to cover many model years beyond those covered by this proposal. In fact, the agency's 2024-2050 analysis period includes model years extending so far beyond those for which this proposal establishes new standards that benefits and costs from changing standards for those later model years dominate the estimated impacts of the standards NHTSA *is* proposing. Key input values for those future years, such as fuel prices, the effects of cumulative production volumes on technology costs, and the effectiveness of those technologies in reducing fuel consumption are also more uncertain, which magnifies uncertainty in the NHTSA-reported results using the calendar year accounting perspective. This increases the significance of NHTSA's assumption that the

[67] Only changes in compliance position are estimated for MYs 2022-2026, which are also covered in the final rulemaking.
[68] The lifetime of each model year is assumed to begin in the calendar year when it is initially produced and sold (assumed to be contemporaneous with its model year designation) and to extend for 40 years. By the time a model year cohort reaches the 40-year mark, fewer than 2 percent of the vehicles originally produced and sold typically remain in use.
[69] To address this shortcoming, NHTSA reports benefits and costs for groups of consecutive model years to recognize that establishing new standards for one model year can affect the number of vehicles from "adjacent" model years that remain in use, how much they are driven, and their fuel consumption, all of which can affect the benefits and costs of setting standards that apply to a single model year.
[70] NHTSA ends its calendar year accounting in CY 2050 since this is the last year for which NHTSA has projections of key inputs, including fuel prices and the macroeconomic variables used to project sales.

2031 CAFE standard will also apply to later model years, as well as its implication that benefits and costs of those assumed standards can be ascribed to this final rule.

5.4. Discounting Future Costs and Benefits

OMB Circular A-4 establishes three rationales for discounting future benefits and costs. The first is that resources invested in capital normally earn a positive return in the future, so it is important to account for the opportunity cost of diverting resources that would otherwise earn those returns to serve a regulation's purpose. Second, people generally prefer current to future consumption, and it is important to account for this effect. Finally, while consumption tends to increase over time due to economic growth, successive increases contribute progressively less to improving economic welfare, making consumption in the future incrementally less valuable than consumption today.[71]

OMB Circular A-4 recommends that Federal agencies provide analysis that discounts future benefits and costs of regulatory actions using both 3-percent and 7-percent discount rates to reflect uncertainty about whether regulations will affect opportunities for investment or households' future consumption.[72] Changes in costs to produce new vehicles that meet revised CAFE standards initially will be borne by vehicle manufacturers. NHTSA assumes that market conditions will either require them to reduce prices to reflect lower costs or to pass cost increases on to buyers via higher prices, ultimately affecting their buyers' other consumption opportunities in either case. Buyers and subsequent owners of new cars and light trucks will experience changes in fuel costs and other effects of CAFE standards over those vehicles' entire lifetimes (typically 15-16 years), and discounting the future reflects the lower importance of those future effects when viewed from today's perspective.

The higher discount rate reflects uncertainty about whether manufacturers can pass any increased costs for providing higher fuel economy forward to buyers, since costs they cannot recover are likely to displace other investment rather than consumption opportunities. Benefits and costs are discounted using both rates to their present values as of 2024 and are expressed in constant dollars reflecting economy-wide price levels prevailing during 2024.

5.5. Reporting Benefits and Costs

NHTSA believes it is important to report the benefits and costs of the alternative CAFE standards in a format that illustrates *how* standards generate economic impacts that ultimately produce benefits and costs, while also highlighting their incidence on households, private businesses, and the remainder of the U.S. population. As an illustration, Table 5-1 presents the categories of estimated economic benefits and costs from setting standards and indicates the specific sections of this PRIA that discuss each category in more detail. For both costs and benefits, the table distinguishes between those experienced by private businesses and households (labeled private costs and benefits), and those experienced more broadly by the United States and global population (labeled "other" costs and benefits in the table below, but sometimes referred to as "external" costs and benefits elsewhere in this PRIA).

Dollar estimates of costs and benefits shown in Table 5-1 for each of the regulatory alternatives considered before selecting the Preferred Alternative for this proposed rule appear in Chapter 0, **Error! Reference source not found.**, and Table 8-15 of this PRIA. These alternative presentations reflect differing perspectives for measuring benefits and costs (model year vs. calendar year, as described in Chapter 5.3 above), and discount rates.

Throughout these tables, positive entries for private costs indicate increases in the value of economic resources vehicle manufacturers would be required to dedicate to complying with new or more demanding CAFE standards or increases in the economic burden on vehicle buyers and owners resulting from higher vehicle prices, sacrifices in other features, and reduced sales—as these compliance costs are reflected in markets for new and used vehicles. Positive external costs reflect adverse economic or safety impacts resulting from vehicle use borne by vehicle users as a whole or by the broader public. In rulemakings such as

[71] OMB Circular A-4.
[72] OMB Circular A-4.

this one, where the agency is proposing to reduce the stringency of CAFE standards, reduced costs represent savings in costs to comply with CAFE standards. Negative entries for private costs reflect savings to manufacturers and vehicle buyers, from reducing the resources vehicle manufacturers would be required to dedicate to complying with CAFE standards when NHTSA reduces their stringency.

As Table 5-1 shows, many impacts of the agency's regulatory actions fall directly on private businesses, households, or individuals, including manufacturers of cars and light trucks, buyers and subsequent owners of the new models they produce, and owners of used vehicles (those produced during model years prior to those considered in this analysis). The largest category of costs from imposing CAFE standards is vehicle producers' expenses for added technology to enable their models to meet higher fuel economy targets; however, as indicated previously, the agency assumes these increased costs will be reflected in higher purchase prices and ultimately borne by new vehicle buyers. Similarly, savings in technology costs and the resulting lower vehicle prices typically represent the largest category of reduced economic costs from reducing the stringency of CAFE standards.

Table 5-1: Benefits and Costs Resulting from the Agency's Regulatory Action

Entry	Location of Explanation in PRIA
Private Costs	
Technology Costs to Change Fuel Economy	Chapter 8.2.3
Increased Maintenance and Repair Costs	Chapter 0
Sacrifice in Other Vehicle Attributes	Chapter 0
Consumer Surplus Loss from Reduced New Vehicle Sales	Chapter 8.3.1, 0
Safety Costs Internalized by Drivers	Chapters 8.4.4, 0
Subtotal—Private Costs	Sum of above entries
External Costs	
Congestion and Noise Costs from Rebound-Effect Driving	Chapter 8.4.2
Safety Costs Not Internalized by Drivers	Chapters 8.4.4
Loss in Fuel Tax Revenue	Chapter 0
Subtotal—Other Costs	Sum of above entries
Total Costs	Sum of private and other costs
Private Benefits	
Savings in Retail Fuel Costs[73]	Chapter 0
Benefits from Additional Driving	Chapter 0
Less Frequent Refueling	Chapter 0
Subtotal—Private Benefits	Sum of above entries
External Benefits	
Reduction in Petroleum Market Externality	Chapter 8.4.3
Reduced Health Damages	Chapters 8.4.1
Subtotal—External Benefits	Sum of above entries

[73] 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.

Total Benefits	Sum of private and external benefits
Net Private Benefits	Private Benefits—Private Costs
Net External Benefits	Other Costs—Other Benefits
Net Total Benefits	Total Benefits—Total Costs

Table 5-1 includes an entry for changes in maintenance and repair costs necessary to ensure that fuel economy is sustained throughout the lifetime of vehicles, although the agency's analysis does not quantify this effect. Maintenance and repair costs represent real potential economic costs of requiring manufacturers to comply with higher standards (or cost savings from reducing the stringency of standards), but the agency lacks sufficient information to estimate them reliably. Other privately borne costs from imposing CAFE standards include losses in consumer surplus to would-be new car and light truck buyers who are deterred by their higher prices, and the increased safety risks that drivers are assumed to consider (or "internalize"). As discussed above, negative entries denote reductions in these various categories of costs.

NHTSA also considers the value to consumers of improvements to other vehicle features that manufacturers may postpone or sacrifice to meet higher fuel economy standards to be a cost; in contrast, lowering CAFE standards reduces these potential costs by enabling manufacturers to focus on improving those other attributes. However, the agency's CAFE Model does not account for any reduction in consumer welfare when raising standards leads manufacturers to change their production of different models in order to comply, or to stop offering certain models altogether. In either case, raising standards distorts the market by precluding manufacturers from offering the complete range of features and models that American consumers value.

Other costs reported in the table include the contributions of additional rebound-effect driving to traffic congestion, delays, and roadway noise. Although delay costs are borne by drivers (and their passengers) *as a whole*, roadway noise also affects pedestrians, nearby residents, and other non-drivers. In either case, individual buyers of new vehicles whose decisions about how much and when to drive impose these costs on others are unlikely to consider such costs when deciding whether to make additional trips. Similarly, those drivers may not account for all safety risks they create for themselves and other road users (especially users who are not vehicle occupants) by making additional trips, and the economic value of these risks represents additional costs they impose on other vehicles' passengers, pedestrians, cyclists, and other road users.

Changes in fuel tax revenue affect the ability of the collecting government agencies to fund road maintenance and other programs with broad-based benefits, so any effects on such revenues are another impact of setting fuel economy standards for buyers of new cars and light trucks.[74] Of course, changes to fuel tax payments by drivers are also reflected in the savings in fuel costs because those are valued at retail prices (which include taxes); thus, the net effect of including both gains and losses from this transfer is zero, as expected.

In NHTSA's CAFE Model, positive values for private benefits reflect increased consumer welfare to purchasers and subsequent owners of new vehicles when they provide higher fuel economy levels required by new or stricter CAFE standards, together with benefits from their resulting additional use. Conversely, negative values for private benefits denote higher fuel expenditure, additional refueling time, or benefits sacrificed by reduced driving. Positive external benefits represent the economic value of reductions in energy market and environmental externalities caused by fuel production and use, whereas negative values reflect increases in the economic costs of these externalities, which typically are felt throughout the U.S. population and economy, rather than being focused on vehicle buyers and users. NHTSA's analysis shows fuel economy and the benefits associated with it continuing to increase over time compared to current conditions even when standards are lowered. This reflects market driven adoption of fuel economy improvements when they are demanded by consumers.

The largest category of benefits from setting CAFE standards is the reduced cost of fuel for buyers of cars and light trucks that achieve higher fuel economy, which Table 5-1 represents as a private benefit. When

[74] NHTSA assumes that states or localities do not respond to declining fuel purchases by raising tax rates to maintain total tax revenues, but still other costs would result if they did so.

estimating the sum of private and external costs and benefits from establishing CAFE standards, the agency assumes that buyers and subsequent owners of new vehicles will value the resulting changes in fuel costs over those vehicles' *entire lifetimes*, rather than just the first 36 months they own and drive them.[75] Thus, as long as further improvements in fuel economy through the addition of technologies with "payback periods" longer than 36 months (3 years) but shorter than vehicles' expected lifetimes (15-16 years) remain available, the agency's analysis will indicate that imposing stricter standards can provide fuel savings and other benefits that would make vehicle buyers and owners *themselves* better off as a result. Setting standards so high that they require manufacturers to employ technology that does not repay its initial cost within vehicles' lifetimes would cause manufacturers' compliance costs—and thus price increases for new cars and light trucks—to offset or exceed the value of fuel savings. In extreme cases, sufficient technology to meet higher standards may simply be unavailable. In either case, setting higher standards will cause economic losses, and these will be particularly large where higher standards no longer lead to additional technology adoption and actual gains in fuel economy.

Those same buyers experience additional benefits from the increased mobility provided by added rebound-effect driving, as well as from the convenience of having to refuel less frequently. These benefits are offset by the additional safety costs and fuel consumption that this additional driving generates. Reducing fuel use provides other benefits to the broader population, including greater energy security resulting from less reliance on fossil fuels and lower exposure to the risk of sharp fluctuations in their prices, as well as improved health from less exposure to harmful levels of air pollution (representing the External Benefits reported in Table 5-1). As the U.S. economy has become less oil intensive over recent decades, while the United States has significantly increased oil production to become a net petroleum exporter, the energy security benefits gained from reduced consumption have declined. As discussed previously, the same values would appear as negative entries when the stringency of CAFE standards is reduced, indicating economic losses rather than gains.

Finally, the table reports Total Costs (the sum of private and external costs) and Total Benefits (the sum of private and external benefits) from setting fuel economy standards. Net Total Benefits are simply the difference between total benefits and costs, with positive values indicating that a given set of CAFE standards is estimated to generate benefits exceeding its costs and negative values would suggest the opposite. In cases such as this proposal where standards are lowered, both costs and benefits as NHTSA measures them will be reduced relative to the baseline, and regulatory alternatives provide net economic benefits if the cost reductions they enable exceed the associated decline in benefits. The table also reports net private benefits (the difference between private benefits and private costs), as well as net external benefits (the difference between external benefits and costs).

[75] Chapter 2 of this PRIA summarizes recent empirical research on these assumptions.

6. Simulating Manufacturers' Potential Responses to the Alternatives

CAFE Model Files Referenced in this Chapter

Below is a list of CAFE Model Files referenced in this chapter. See Draft TSD Chapter 2.1.9 "Where to Find the Internal NHTSA Files" for a full list of files referenced in this document and their respective file locations.

- Market Data Input File
- Technologies Input File
- Scenarios Input File
- CAFE Model Documentation
- CAFE Model Input File
- CAFE Analysis Autonomie Documentation

The CAFE Model utilizes a variety of data and algorithms to characterize real world vehicle fleets, fuel-saving technology, and real world technical and economic factors to build an assessment of how each manufacturer could comply with a given regulatory alternative.[76] The CAFE Model compliance analysis includes detailed information about each regulated manufacturer's vehicle models offered for sale in a given model year (or years), production constraints, compliance strategies, and manufacturers' application of AC and OC efficiency technologies (for years in which manufacturers may generate fuel consumption improvement values (FCIV) for these technologies).[77] The regulatory alternatives, while applicable to all manufacturers in the analysis, affect individual manufacturers differently. Each manufacturer's actual fuel economy compliance approach represents the production-weighted harmonic mean of their vehicles' targets in each regulated fleet, where the fuel economy target is a function of the vehicles' footprints. This means that no individual vehicle has a "standard," merely a target, and each manufacturer is free to identify the most sensible compliance strategy given its unique combination of vehicle models, consumers, and competitive position in the various market segments. As the CAFE Model provides flexibility when defining a set of fuel economy standards, each manufacturer's requirement is dynamically defined based on the specification of the standards for any simulation and the distribution of footprints within each fleet.

6.1. Representing Manufacturer's Decisions

In the real world, vehicle manufacturers make choices about which technologies are appropriate to apply in response to fuel economy regulations. To simulate these decisions, the CAFE Model considers a number of factors, including a manufacturer's current technology, the array of fuel-saving technologies available, the cost of such technologies, and a variety of real world constraints related to vehicle manufacturing and sale.[78] The CAFE Model ultimately chooses technologies that, for a certain manufacturer's vehicle fleet, would offer the most cost-effective path toward compliance with fuel economy standards.

The first step to represent manufacturers' decisions about which fuel economy-improving technologies could be applied to their vehicles in a future model year is to define the relevant list of technologies available for application, after considering the statutory limitations on NHTSA's standard-setting analysis. The CAFE Model includes extensive technology options and pathways available for application to vehicles. These technologies and pathways are detailed in Draft TSD Chapters 2 and 3, and they include restrictions around which more advanced technologies can be applied based upon already-applied technologies. The Model selects the most cost-effective technologies, subject to additional constraints discussed below, which allow manufacturers to meet fuel economy standards.

The Market Data Input File forms the starting point for the CAFE Model analysis. It includes detailed information about the vehicle models available for sale and their respective fuel-saving technologies; the model years for which the CAFE Model will have opportunities to apply technology; what engines,

[76] For a complete discussion on all input options available in the Market Data Input file please see the CAFE Model Documentation. This chapter focuses on the CAFE Model compliance simulation in the standard-setting analysis.
[77] See preamble Section VI.
[78] 49 U.S.C. 32902(h).

transmissions, and platforms are shared between vehicles; vehicle sales, fuel economy, footprints, and safety classes; and various other pieces of information used to make the compliance simulation more realistic.[79,80]

The effectiveness of each technology is based on simulations run from Argonne's Autonomie model.[81,82] Argonne runs ten sets of simulations that differ by vehicle "technology class." Technology classes are used to accurately represent how vehicles with different characteristics may benefit from fuel economy-improving technologies. All vehicles in the Market Data Input File are assigned a technology class that allows the Model to use the effectiveness values that most closely match a vehicle's characteristics.[83] The vehicle classification discussed in Draft TSD Chapter 2.7 is not expected to impact the assignment of vehicle technology class.

The costs of each technology considered in this analysis are stored in the Technologies Input File.[84] The costs are either assigned by vehicle technology class or engine class, depending on whether a technology is deemed a platform technology or an engine technology. All technology costs represent an average direct manufacturing cost with a retail price equivalent factor of 1.5 and decrease in successive model years based on a learning rate that represents manufacturers becoming more efficient at producing a technology over time. The costs of batteries, such as those used in hybrid-electric vehicles, are included in the CAFE Model and the Technologies Input File with a battery learning rate that allows those costs to decrease in future years.[85]

Some technologies may have Federal tax incentives tied to their application, which are included in the modeling where applicable. The Scenarios Input File includes tax credits applicable to vehicles, batteries, or both during the years modeled. These incentives are defined by regulatory class and technology. If battery tax credits are applied for plug-in hybrid electric vehicles (PHEVs), their magnitude is based on the average PHEV battery pack size. Incentives such as these reduce the cost to manufacturers of applying a technology.

Technology application in the CAFE Model is determined by the "effective cost" of a technology. For this analysis, the effective cost of a technology represents the tradeoffs that manufacturers make between regulatory costs and consumer demand for fuel economy improvements, among other factors. Thus, the calculation of effective cost includes the incremental cost of the technology itself, the value of fuel savings to a potential buyer over the first 36 months of ownership,[86] and the value of any vehicle and battery tax credits (Federal incentives) resulting from application of a candidate technology evaluated on a group of selected vehicles.[87] The CAFE Model attempts to apply technology to each manufacturer's fleet in a manner that minimizes these effective costs. CAFE Model Documentation Chapter 2 Section 5.3.2 includes an in-depth discussion of the relevant effective cost equations.

This construction allows the Model to choose technologies that both improve a manufacturer's compliance position and are attractive to consumers. It also means that different assumptions about future fuel prices will produce different rankings of technologies when the Model evaluates available technologies for application. For example, if gasoline prices are forecasted to be low, an expensive but very efficient technology may not look attractive to manufacturers because the value of the fuel savings is insufficiently high and it does not counteract the higher cost of the technology and, implicitly, does not satisfy consumer demand to balance price increases with reductions in operating cost. The Model continues to add technology until a manufacturer:

- reaches compliance with fuel economy standards;

[79] See Draft TSD Chapter 2 for additional details about the Market Data Input File.
[80] See the Market Data Input File, which can be found on the NHTSA CAFE Model website.
[81] Technology effectiveness values are included in the CAFE Model release and are not selectable by the user.
[82] For more information about how the Autonomie model was used, see the CAFE Analysis Autonomie Documentation. Note: 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 Draft TSD, it is referred to as "CAFE Analysis Autonomie Documentation."
[83] See Draft TSD Chapter 3 for additional details about technology effectiveness values.
[84] See the Technologies Input File, which can be found on the NHTSA CAFE Model website.
[85] See Draft TSD Chapter 2 and Draft TSD Chapter 3 for more discussion on specific technology costs and technology types.
[86] The length of time over which to value fuel savings in the effective cost calculation is a model input that can be modified by the user. This analysis uses 36 months' worth of fuel savings in the effective cost calculation, assuming that the price of fuel at the time of purchase persists for at least the next 36 months. This implies that new car buyers will behave as if the fuel price at the time of purchase reflects the fuel price they will face over the life of the vehicle. The accompanying PRIA Chapters 3 and Draft TSD Chapter 4.2.1 discuss the basis for this model input.
[87] See Draft TSD Chapter 2 that explains changes to Federal incentives due to OB3 (tax credits).

- reaches a point at which a manufacturer has exhausted all the possible technology options for its fleet and still falls short of compliance (niche technologies such as MR5 are not applicable to be adopted); or
- reaches a point beyond compliance where the cost of additional fuel-saving technology begins to exceed the fuel savings projected to occur during the first 36 months of vehicle ownership.

The algorithm stops applying additional technology to a manufacturer's vehicles once one of the above criteria is met.[88] This process is repeated for each manufacturer present in the input fleet and then for each model year. Once all model years have been processed, the compliance simulation algorithm concludes.

The effective cost equations work with a set of rules that determine which technologies are available for application and in what quantity. These rules reflect real world production constraints that influence manufacturers' compliance options and are relevant to evaluating the economic practicability of different regulatory alternatives. While the earliest CAFE analyses did not account for all of these constraints, both public comments on earlier rules and CAFE Model peer reviewers have consistently found them to be relevant and meaningful inclusions.[89] Examples of constraints applied in the Model include phase-in caps, technology sharing, and skip logic. Phase-in caps limit how much of a certain technology can be applied in a given model year. Technology sharing of engines, transmissions, and platforms restricts technology application so that sharing cannot be broken with the exception with certain hybridization technologies. Some technologies might be skipped for specific vehicle types or manufacturers. These constraints work together in the Model to reflect manufacturers' technology application decisions in the compliance simulation. As discussed in the preamble, NHTSA's standard-setting analysis does not consider factors prohibited under 49 U.S.C. 32902(h). Therefore, the CAFE Model applies additional rules for the standard-setting analysis, which are discussed in further detail in Chapter 2 of the Draft TSD.

6.2. Vehicle Technology Compliance Examples

As discussed in NPRM preamble Section VI, NHTSA is proposing to make changes to how vehicles are classified into the passenger automobile and non-passenger automobile regulatory classes for compliance purposes. While compliance positions are evaluated at the manufacturer fleet level, incremental changes to a manufacturer's CAFE position are driven by sales-weighted technology adoption at the vehicle level.

As discussed in PRIA Chapter 8, these compliance changes are being evaluated in conjunction with re-establishing the footprint-based CAFE fuel economy curves based on how vehicles are allocated with the proposed classification changes. This means that MY 2026 curve coefficients are based on the current fleet classification criteria, the MY 2028 curve coefficients are based on the new proposed classification criteria, and MY 2027 curve coefficients are a linearly interpolated transition year where vehicles will remain in their existing fleets with AC/OC credits available. For further discussion of curve development and how these standards were set, see PRIA Chapter 3.

Due to the reshaping of the curves to account for the new fleet allocations, the impact on individual automobiles varies significantly depending on the fleet in which that vehicle resides before and after the proposed MY 2028 reclassification and the footprint of that vehicle. For purposes of this illustration, target values are based upon the Preferred Alternative. Accordingly, this section shows the following examples:

Table 6-1: Technology Compliance Example Vehicles

Vehicle	2024 Starting Tech	2024-2027 Fleet	2028+ Fleet	Footprint
Toyota Grand Highlander	TURBO0; AT8L2; SS12V; ROLL0; AERO5; MR3	LT	PC	54.6
Toyota Grand Highlander	SHEVPS; ROLL0; AERO5; MR3	LT	PC	54.6

[88] See Chapter 2 Section 5 of the CAFE Model Documentation for a full explanation of how the compliance simulation works. The criteria for adding technology can vary depending on runtime settings and inputs.
[89] For a detailed description of the CAFE Model Input File please see the CAFE Model Documentation.

Subaru Crosstrek	DOHC; SGDI; CVT; SS12V; ROLL0; AERO5; MR1	LT	PC	44.7
Jeep Wrangler	TURBO2; AT8; SS12V; ROLL30; AERO0; MR0	LT	LT	42.3
Genesis G90	TURBO0; AT8; SS12V; ROLL0; AERO10; MR1	PC	PC	56.8

The following Table 6-2 through Table 6-6 and corresponding Figure 6-1 through Figure 6-4 show each example vehicle's technology progression and compliance position beginning in the MY 2024 reference fleet through MY 2031. In the figures, the years shown preceding the proposed AC/OC and classification changes (MYs 2024-2027) are shaded blue, and the years shown after the proposed changes have taken effect (MYs 2028-2031) are shaded green.

Table 6-2: Toyota Grand Highlander TURBO CAFE Model Tech and FE Compliance

Model Year	Technology	Achieved CAFE MPG	Target CAFE MPG
2024	TURBO0; AT8L2; SS12V; ROLL0; AERO5; MR3	29.7	35.1
2025	TURBO0; AT8L2; SS12V; ROLL0; AERO5; MR3	29.7	38.2
2026	TURBO0; AT8L2; SS12V; ROLL0; AERO5; MR3	29.7	42.4
2027	TURBO0; AT8L2; SS12V; ROLL30; AERO5; MR3	31.8	28.1
2028	TURBO0; AT8L2; SS12V; ROLL30; AERO5; MR3	31.8	32.2
2029	TURBO0; AT8L2; SS12V; ROLL30; AERO5; MR3	31.8	32.3
2030	TURBO0; AT8L2; SS12V; ROLL30; AERO15; MR4	33.6	32.4
2031	TURBO0; AT8L2; SS12V; ROLL30; AERO15; MR4	33.6	32.5

Table 6-3: Toyota Grand Highlander SHEVPS CAFE Model Tech and FE Compliance

Model Year	Technology	Achieved CAFE MPG	Target CAFE MPG
2024	SHEVPS; ROLL0; AERO5; MR3	47.2	35.1
2025	SHEVPS; ROLL0; AERO5; MR3	47.2	38.2
2026	SHEVPS; ROLL0; AERO5; MR3	47.2	42.4
2027	SHEVPS; ROLL30; AERO5; MR3	52.6	28.1
2028	SHEVPS; ROLL30; AERO5; MR3	52.6	32.2
2029	SHEVPS; ROLL30; AERO5; MR3	52.6	32.3
2030	SHEVPS; ROLL30; AERO15; MR4	56	32.4
2031	SHEVPS; ROLL30; AERO15; MR4	56	32.5

Figure 6-1: Toyota Grand Highlander All-Wheel Drive (AWD) Compliance FE vs. CAFE Target FE

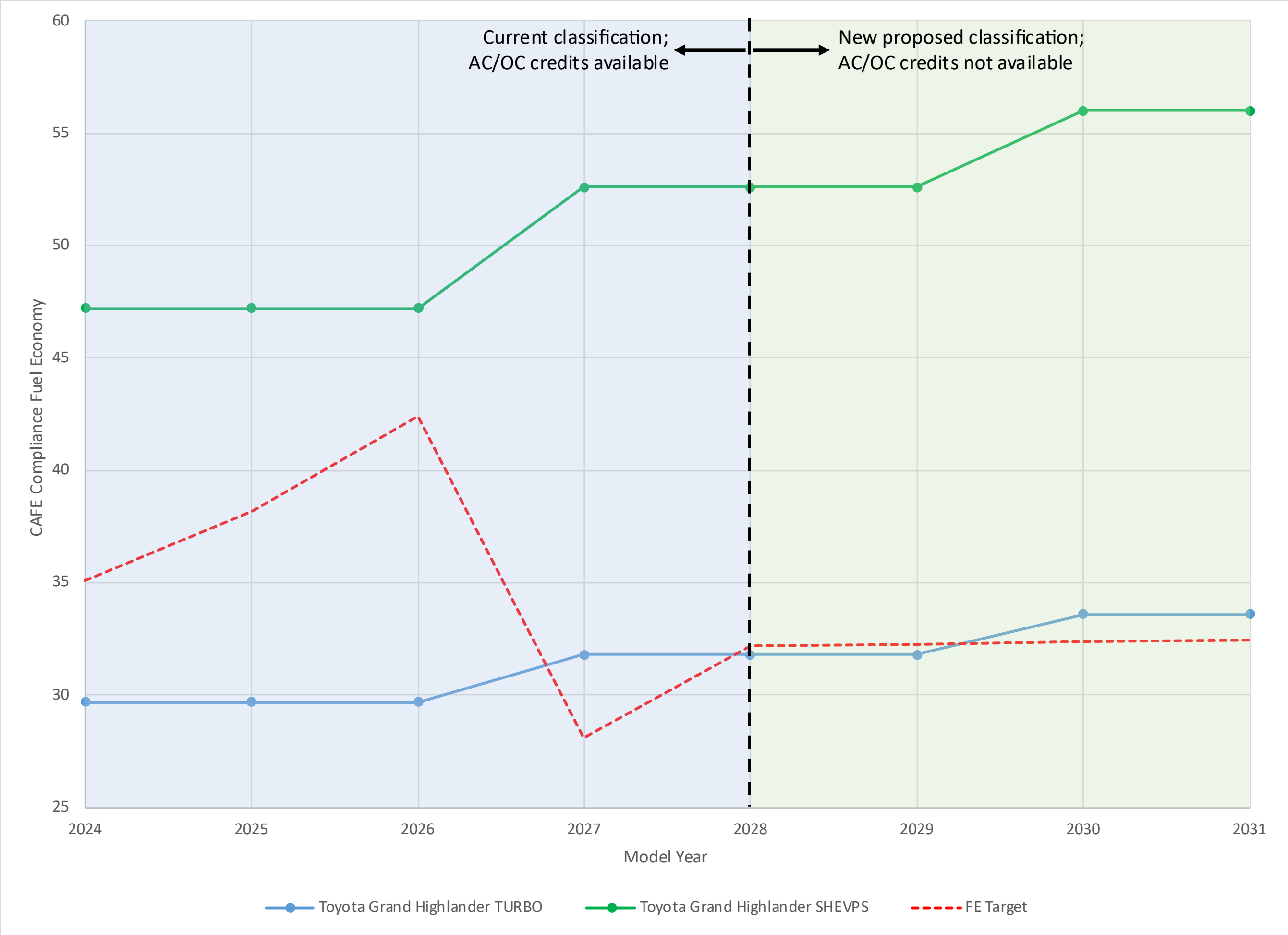


Table 6-4: Subaru Crosstrek 2.5L CAFE Model Tech and FE Compliance

Model Year	Technology	Achieved CAFE MPG	Target CAFE MPG
2024	DOHC; SGDI; CVT; SS12V; ROLL0; AERO5; MR1	39.2	41.4
2025	DOHC; SGDI; CVT; SS12V; ROLL0; AERO5; MR1	39.2	45.0
2026	DOHC; SGDI; CVT; SS12V; ROLL0; AERO5; MR1	39.2	50.0
2027	DOHC; SGDI; CVT; SS12V; ROLL30; AERO5; MR1	41.7	33.8
2028	DOHC; SGDI; CVT; SS12V; ROLL30; AERO5; MR1	41.7	40.6
2029	DOHC; SGDI; CVT; SS12V; ROLL30; AERO5; MR1	41.7	40.7
2030	DOHC; SGDI; CVT; SS12V; ROLL30; AERO5; MR1	41.7	40.8
2031	DOHC; SGDI; CVT; SS12V; ROLL30; AERO5; MR1	41.7	40.9

Figure 6-2: Subaru Crosstrek 2.5L Compliance FE vs. CAFE Target FE

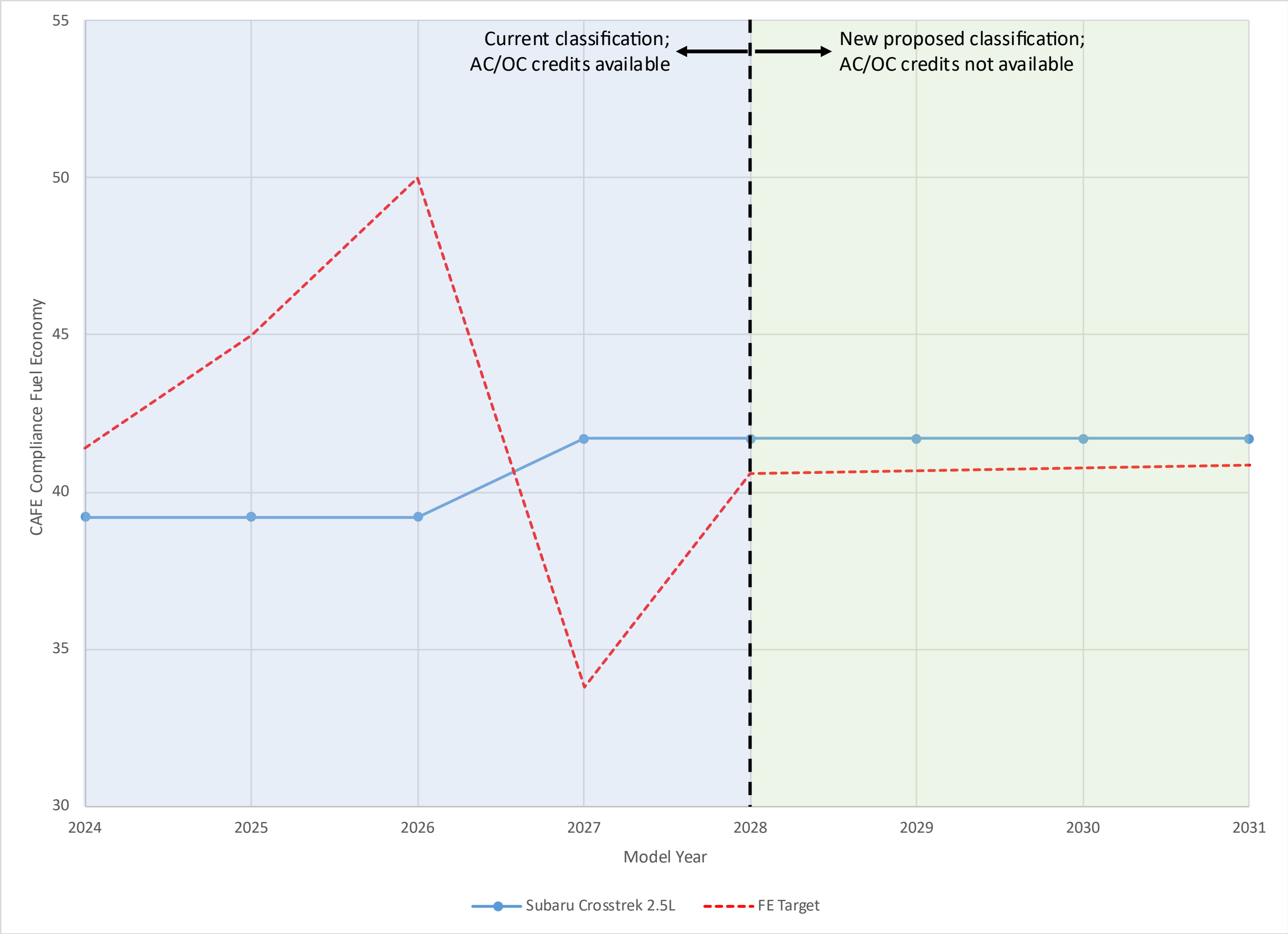


Table 6-5: Jeep Wrangler 2dr 4x4 Turbo CAFE Model Tech and FE Compliance

Model Year	Technology	Achieved CAFE MPG	Target CAFE MPG
2024	TURBO2; AT8; SS12V; ROLL30; AERO0; MR0	29.2	43.3
2025	TURBO2; AT8; SS12V; ROLL30; AERO0; MR0	29.2	47.1
2026	TURBO2; AT8; SS12V; ROLL30; AERO0; MR0	29.2	52.4
2027	TURBO2; AT8; SS12V; ROLL30; AERO15; MR0	30.3	35.6
2028	TURBO2; AT8; SS12V; ROLL30; AERO15; MR0	30.3	31.5
2029	TURBO2; AT8; SS12V; ROLL30; AERO15; MR0	30.3	31.5
2030	TURBO2; AT8; SS12V; ROLL30; AERO15; MR0	30.3	31.6
2031	TURBO2; AT8; SS12V; ROLL30; AERO15; MR0	30.3	31.7

Figure 6-3: Jeep Wrangler 2dr 4x4 Turbo Compliance FE vs. CAFE Target FE

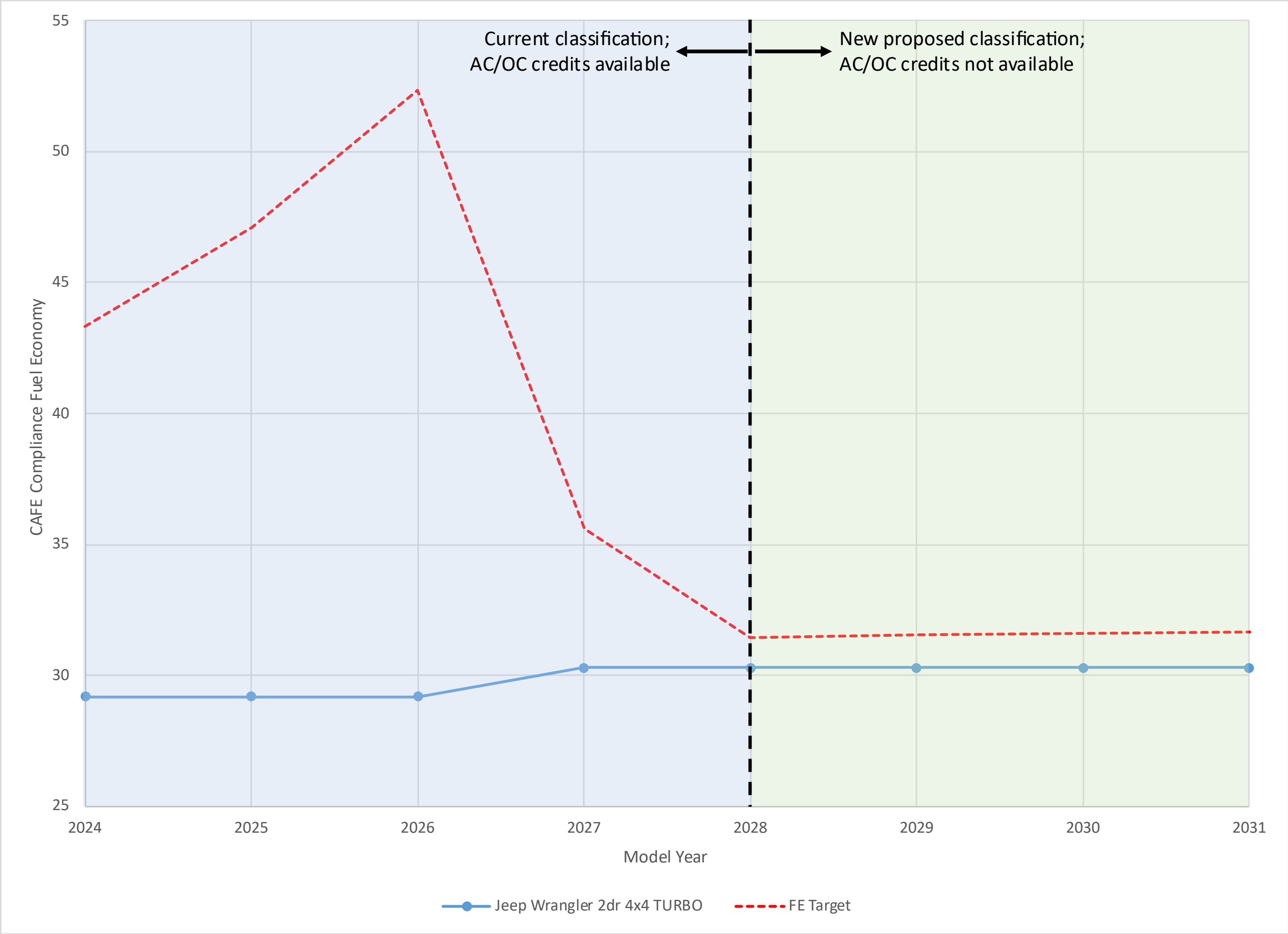
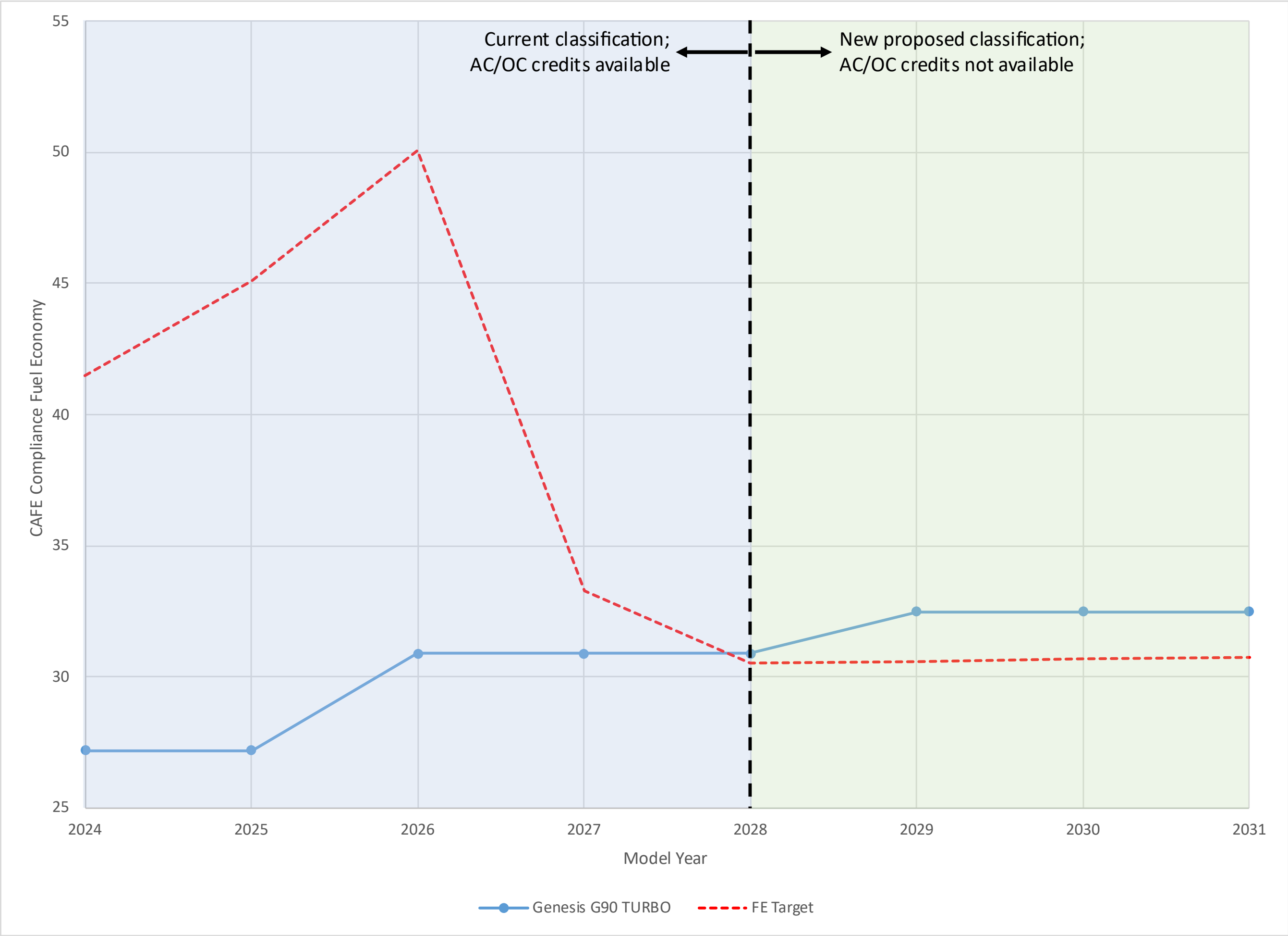


Table 6-6: Genesis G90 3.5T AWD CAFE Model Tech and FE Compliance

Model Year	Technology	Achieved CAFE MPG	Target CAFE MPG
2024	TURBO0; AT8; SS12V; ROLL0; AERO10; MR1	27.2	41.5
2025	TURBO0; AT8; SS12V; ROLL0; AERO10; MR1	27.2	45.1
2026	TURBO0; AT10L3; SS12V; ROLL20; AERO10; MR1	30.9	50.1
2027	TURBO0; AT10L3; SS12V; ROLL20; AERO10; MR1	30.9	33.3
2028	TURBO0; AT10L3; SS12V; ROLL20; AERO10; MR1	30.9	30.5
2029	TURBO0; AT10L3; SS12V; ROLL20; AERO15; MR3	32.5	30.6
2030	TURBO0; AT10L3; SS12V; ROLL20; AERO15; MR3	32.5	30.7
2031	TURBO0; AT10L3; SS12V; ROLL20; AERO15; MR3	32.5	30.7

Figure 6-4: Genesis G90 3.5T AWD Compliance FE vs. CAFE Target FE



7. Simulating Consumers' Potential Responses to and Related Impacts from Regulatory Alternatives

7.1. Impacts on Markets for New and Used Vehicles

Impacts of setting or modifying CAFE standards are traceable to compliance decisions made by manufacturers and the resulting changes in the sales prices and operating costs of new vehicles. This chapter outlines the process by which costs associated with complying with fuel economy standards and the accompanying changes in the operating costs of vehicles are transmitted through interconnected markets to generate various economic costs and benefits.

First, NHTSA assumes that vehicle manufacturers will be able to recover their incremental costs for producing vehicles that meet higher fuel economy targets by raising selling prices for at least some models. The agency does not attempt to estimate price increases for specific car or light truck models, and instead assumes that the *average* price of vehicles across each manufacturer's fleet will rise sufficiently that increased sales revenue fully covers manufacturers' increased costs. Conversely, NHTSA assumes that any savings in manufacturers' costs when the agency reduces the stringency of CAFE standards will be reflected in lower prices for new cars and light trucks.

NHTSA's analysis also accounts for the fuel economy of future vehicles that manufacturers would build even in the absence of CAFE standards. The agency assumes that learning effects will reduce the costs of existing technology and enable gradual improvement in fuel economy over time even without changes in CAFE requirements, since reducing costs will broaden the range of technologies that repay their initial costs within buyers' assumed 36-month payback period. The agency's analysis accounts for fuel economy improvements manufacturers could make in response to increasing fuel prices, as the increased value of fuel savings over the 36-month payback period prompts vehicle buyers to seek vehicles with higher fuel economy.[90]

NHTSA's analysis also assumes that manufacturers will not compromise other attributes of models whose fuel economy they improve, and will thus incur the incremental costs of technology necessary to meet higher standards without changing those other features.[91] However, manufacturers may postpone, modify, or even forgo planned future improvements in some models' other features as they attempt to comply with past CAFE standards while minimizing impacts on prices, vehicle sales, and profitability. Any resulting loss in utility those models offer represents an additional cost of meeting CAFE standards, because it limits the range of options available to buyers, and this cost is frequently overlooked. However, in this rulemaking, these impacts are reduced or eliminated by resetting previously adopted standards. NHTSA's analysis estimates this "implicit opportunity cost" of CAFE standards to new car and light truck buyers.

The welfare effects of setting standards also include any losses in manufacturers' profits ("producer surplus") stemming from their inability to raise their models' selling prices sufficiently to recover increases in their production costs for meeting tougher standards. Without detailed models of manufacturers' costs to produce vehicles offering different combinations of fuel economy and other features, and the effect of vehicles' prices and features on sales and market shares of competing models, NHTSA is unable to estimate the magnitude of manufacturers' losses.[92] Instead, the agency makes several simplifying assumptions that enable approximation of the economic costs and benefits of imposing CAFE standards.

Manufacturers' use of more advanced technology to improve fuel economy may also change vehicle buyers' and owners' maintenance or repair expenses. Although some minor deterioration in vehicles' fuel economy as they age and accumulate use is normal, additional maintenance and repairs to sustain vehicles' original fuel economy (and other capabilities) would represent changes in the cost of requiring new vehicles to meet

[90] NHTSA's economic evaluation of standards also accounts for the fuel savings that buyers of new vehicles (and any later vehicle owners) experience over their vehicles' entire lifetimes as a benefit from requiring higher fuel economy.
[91] Gradual technological progress in vehicle design and production methods may enable manufacturers to improve vehicle fuel economy slowly over time at no cost, thus reducing their incremental costs to meet higher targets, but NHTSA's analysis does not account for this potential effect and may thus overstate compliance costs slightly.
[92] Much of the information necessary to estimate cost increases, higher prices for specific models, and changes in their sales is held closely by manufacturers and not publicly available.

higher fuel efficiency standards.[93] While NHTSA does not attempt to estimate such expenses, including them would increase its estimates of the costs to meet CAFE standards.

The agency first assembles data on sales, prices, fuel economy, and other attributes of the car and light truck models produced during MY 2024 (the "reference fleet").[94] NHTSA projects how manufacturers might change the fuel economy of their model lineups if the agency took no action, including attempting to comply with prevailing fuel economy standards, responding to buyers' demand for fuel economy, or taking advantage of normal improvements in technology. Using this No-Action Alternative as a reference fleet, the agency's CAFE Model simulates how each manufacturer might change the fuel economy of models in the reference fleet to comply with alternate CAFE standards for future model years that are considered and evaluated in the proposal.

7.1.1. Near-Term Effects in the Market for New Vehicles

Changes in selling prices, fuel economy, and other features of new cars and light trucks affect both the sales of individual models and the total number of new vehicles sold. Changes in prices and fuel economy resulting from manufacturers' efforts to comply with higher CAFE standards are likely to reduce the number of new vehicles sold, as NHTSA's regulatory analysis assumes that without higher standards, manufacturers would improve fuel economy as long as doing so repays their initial costs—and the higher prices they charge to recover those costs—within buyers' assumed 36-month payback period. Any further increase in fuel economy to meet more stringent CAFE standards would produce fuel savings that buyers value at less than manufacturers' costs to make them, so when producers raise prices to reflect those added costs, some potential buyers will opt out of the new car market.

The underlying logic is that if manufacturers believe that potential buyers sufficiently value higher fuel economy such that improving it while raising vehicle prices to cover their higher costs would increase sales, manufacturers would do so even in the absence of higher standards because their profits would rise. Conversely, reducing the stringency of CAFE standards saves manufacturers' costs and reduces car and light truck prices by more than fuel cost increases within the 36-month payback period, drawing potential buyers into the new car market.

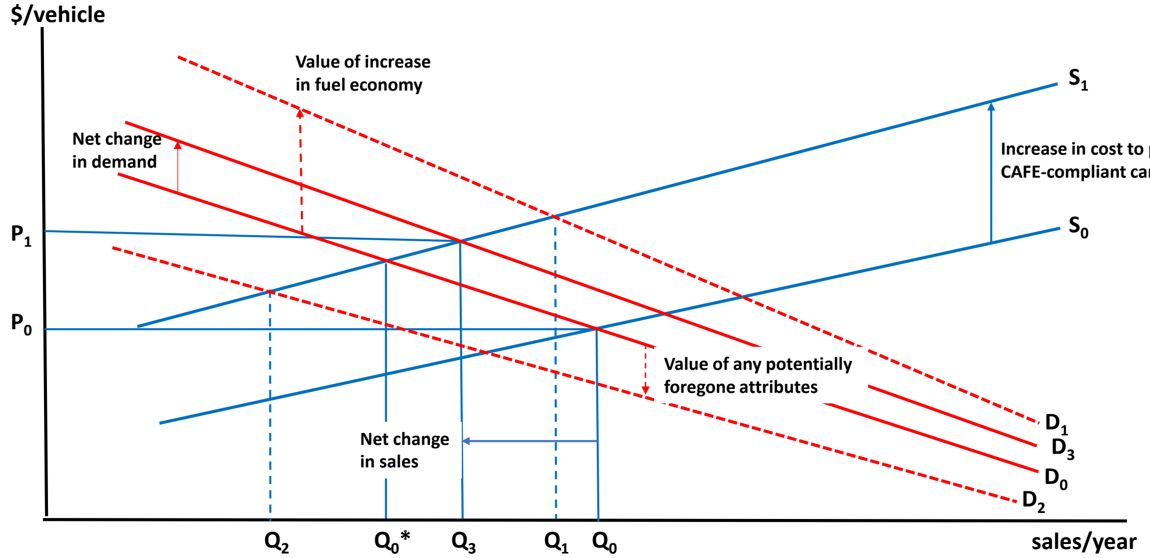
The relative importance of prices, fuel economy, and vehicles' other attributes to potential buyers of new models has not been quantified well in research to date. Their relative importance is also likely to vary widely among consumers, so it is difficult to anticipate the combined effect of changes in these features on sales of new vehicles and the market shares of individual models.

Figure 7-1 illustrates the likely near-term effect of setting or raising fuel economy standards on total sales of new cars and light trucks; the effect of lowering fuel economy standards would be symmetric, with each movement of the supply and demand curves occurring in the opposite direction. Under the reference baseline, total demand for new vehicles is shown by the demand curve D_0, which relates to the number of new vehicles that would be purchased at a given sales price. The industry-wide supply curve, which depicts the number produced during a model year and offered for sale at each price, is shown by S_0 in the figure. In the reference baseline, demand and supply interact to result in total sales of Q_0 vehicles at a price of P_0.

Increasing the amount of fuel economy-improving technology that manufacturers must employ by setting or raising CAFE standards increases their costs to produce new vehicles, which is shown as an upward shift in the industry-wide supply curve to S_1. To preserve profitability, manufacturers raise prices to reflect their increased costs (on average across their entire model lineups, if not necessarily for each individual model). If there were no accompanying change in demand, annual sales would decrease to the level Q_0^*, where the original demand curve D_0 intersects the new supply curve S_1.

[93] See Burnham A. et al., Comprehensive Total Cost of Ownership Quantification for Vehicles with Different Size Classes and Powertrains, ANL/ESD-21/4, ANL: Washington, DC (2021), available at: https://doi.org/10.2172/1780970 (accessed: Sept. 10, 2025).
[94] See Chapter 2 of the Draft TSD.

Figure 7-1: Effect of Changes in Price, Fuel Economy, and Other Attributes on Demand and Sales of New Vehicles[95]



The fuel economy of new models will also change, as their manufacturers employ more advanced technology to increase fuel economy. However, manufacturers also potentially will forgo some improvements they would otherwise have made in those models' other useful features. Both changes will affect consumer demand for new vehicles but in opposite directions. Increasing fuel economy reduces vehicles' operating costs, improving their appeal to buyers; by itself, this would shift demand for new vehicles upward. For illustrative purposes, NHTSA shows an upward shift to the level shown by the demand curve D_1 in Figure 7-1, and higher demand would limit the decline in sales when their prices increase to (Q_0-Q_1).[96]

At the same time, forgoing improvements to vehicles' other features as manufacturers increase fuel economy reduces new models' desirability to potential buyers and lowers market demand, as illustrated in Figure 7-1 by the downward shift in the demand curve to D_2. In conjunction with higher prices that reflected manufacturers' added costs, the sacrifice in improvements to vehicles' other features would reduce their sales to Q_2 if it were not accompanied by improved fuel economy.

The net effect of these two changes on demand for new cars and light trucks is difficult to anticipate because it depends on the specific changes in fuel economy and vehicles' other features that manufacturers make, the increase in prices, and the distribution of values buyers place on fuel economy and other attributes. If potential buyers view the combination of higher fuel economy and sacrifices in new vehicles' other features as making them less desirable on net, sales will decline in response to their higher prices. Figure 7-1 shows that if buyers view the combination of higher fuel economy, and changes in vehicles' other features as making them *more* desirable, demand for new vehicles would shift upward to a position such as D_3 and their price would rise to P_1. Nevertheless, sales would still decline (to Q_3), as the effect of higher prices outweigh the increase in new vehicles' desirability, which the agency believes is the likely outcome.

Reducing the stringency of CAFE standards would produce exactly the opposite result, by instead shifting the supply curve downward from S_0 Figure 7-1. If buyers viewed improvements to new models' other features as outweighing the effect of their lower fuel economy, demand would rise from its initial level D_0, and sales would unambiguously increase. Even if buyers took the opposite view and demand declined instead, NHTSA

[95] Note: This graph represents the impacts from a hypothetical change in the rule, not from this proposed rule, and does not show the impact of other policies. To see how NHTSA has modeled other policies, please see Draft TSD Chapter 2.

[96] The specific form of the upward shift in demand shown in the figure—a larger upward shift at lower sales levels—reflects a presumed distribution of buyers' valuations of higher fuel economy, with those toward the upper (or left) end of D_1 willing to pay the most for increased fuel economy, while buyers with progressively lower values of improved fuel economy entering the market moving down and to the right along D_1. This distribution would arise, for example, if buyers who intend to drive more were willing to pay more for models offering higher fuel economy, which seems likely.

estimates that sales of new cars and light trucks would still likely increase as the combination of lower prices and improved features outweighed the disadvantage of lower fuel economy.

7.1.2. Near-Term Effects on the Used Vehicle Market

By affecting the fuel economy, selling prices, and other features of new vehicles, setting CAFE standards not only affects sales of new vehicle models, but also increases the demand for used vehicles. Used vehicles—especially those produced during recent model years—offer a close potential substitute for new models, so an increase in prices forced by higher CAFE standards will drive consumers to purchase cheaper used models instead. This increase in demand affects the market value and selling prices of used vehicles of various ages—not just relatively new ones—as it “ripples through” the used vehicle fleet and influences some owners’ decisions about whether to make the repairs necessary to keep much older models in service and how much to drive them.

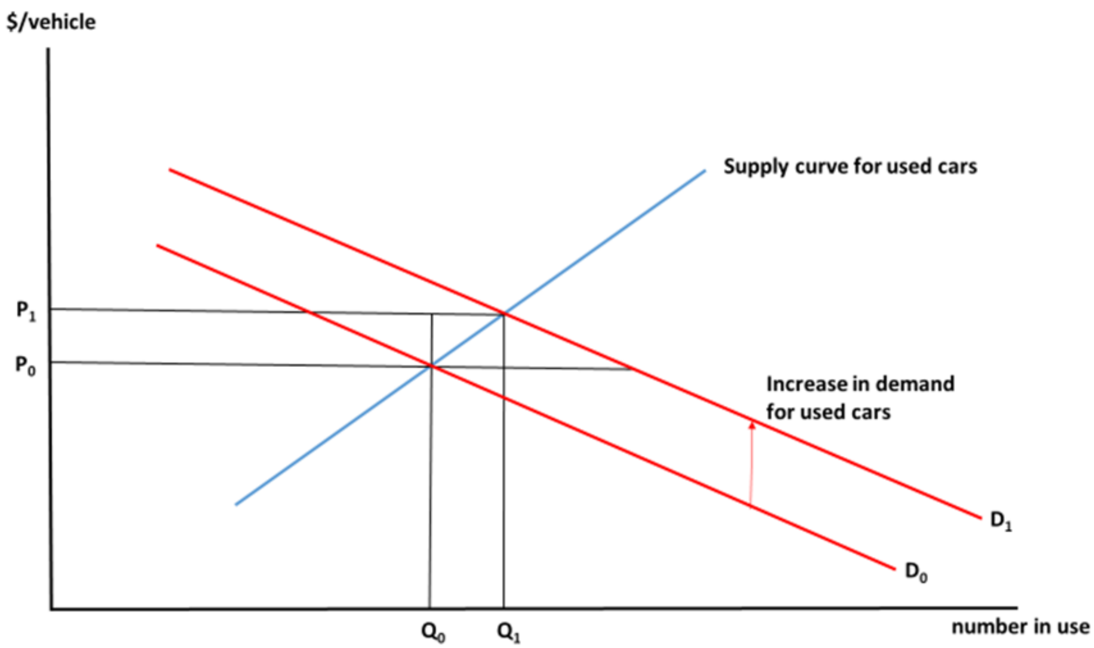
Regulations on new vehicles can also directly affect vehicle durability and retirement rates over their lifetimes by changing how much it costs to repair and maintain them, which affects their owners’ decisions about how long to keep their used vehicles in service. Changes in the number of used vehicles kept in service and how much they are driven can have important consequences for overall fuel consumption, safety, and emissions of criteria air pollutants, which offset benefits from fuel economy standards. The indirect effect of regulations that raise prices for new vehicles on the size and utilization of the used vehicle fleet has been well-documented and is the subject of extensive empirical research.[97]

Figure 7-2 illustrates the immediate effects of setting standards on the market for used cars and light trucks. Faced with higher prices for new models that offer improvements in fuel economy beyond what they are willing to pay, some households and businesses will choose to rely on used cars or light trucks as an alternative to purchasing new ones. Their decisions to do so will increase demand for used vehicles, shifting the demand curve for used models in the figure from its original position at D_0 outward to D_1. When standards are lowered, prices for new vehicles will be relatively lower, which weakens demand for used vehicles and shifts the demand curve inward from D_1.

Shifts in demand for used vehicles of different ages in response to changes in the prices and attributes of new models are likely to mirror how closely they substitute for their new counterparts. Nearly new vehicles offer the closest substitute for new ones, so their demand is likely to be most responsive to changes in prices and other characteristics of new ones. In contrast, the outdated features and accumulated usage of older vehicles make them less satisfactory substitutes, so their demand is likely to be less responsive to higher prices for new models. Thus, it is likely that the demand for nearly new vehicles will increase most when prices for new models rise, while increases in the demand for progressively older vehicles will be smaller.

[97] This result is often referred to as the “Gruenspecht effect,” after one of the earliest researchers to identify its importance. See Gruenspecht, H., Differentiated Regulation: The Case of Auto Emissions Standards, *American Economic Review*, Vol.72(2): pp. 328 – 31 (1982), available at: https://www.taylorfrancis.com/chapters/edit/10.4324/9781351161084-5/differentiated-regulation-case-auto-emissions-standards-howard-gruenspecht (accessed: Sept. 10, 2025).

Figure 7-2: Effect of CAFE Standards on the Market for Used Vehicles



In Figure 7-2, the position of the supply curve for used vehicles reflects the initial size of the used vehicle fleet at the outset of the period, which in the agency's analysis is the current model year and corresponding calendar year. Though the supply of used vehicles is relatively insensitive to changes to price (or "inelastic"), it is not fixed. For example, owners can increase the number of used vehicles that are available by spending more on the maintenance and repairs necessary to keep older models in service rather than retiring them. This is shown by the upward-sloping supply curve in Figure 7-2, which reflects repairs and maintenance necessary to increase the number of used vehicles in usable condition becoming increasingly costly as owners who would otherwise have retired their progressively older vehicles decide instead to keep them in use.

The interaction of increased demand for used models and the upward sloping supply curve causes the average market value and selling price of used vehicles to rise, from P_0 to P_1 in Figure 7-2. Some owners who would have preferred to buy a new vehicle and retire their used vehicles in the absence of CAFE standards will find that the combination of higher new vehicle prices and the higher market value for their used vehicle justifies the expense of the added maintenance and repairs necessary to keep their current vehicle in use longer. So, the increase in the prices of used vehicles will raise the number remaining in service, from Q_0 to Q_1. Because the market for used vehicles is very active—annual sales of used vehicles have averaged nearly three times the number of new models sold in recent years—these responses are likely to be rapid. This process will slow the turnover of the Nation's vehicle fleet from its pace under the reference baseline, by reducing the rate at which new models enter the fleet to replace used vehicles that are retired. Coupled with the reduction in sales of new vehicles, keeping more used models in service will also effectively "transfer" some travel from new vehicles to older models.

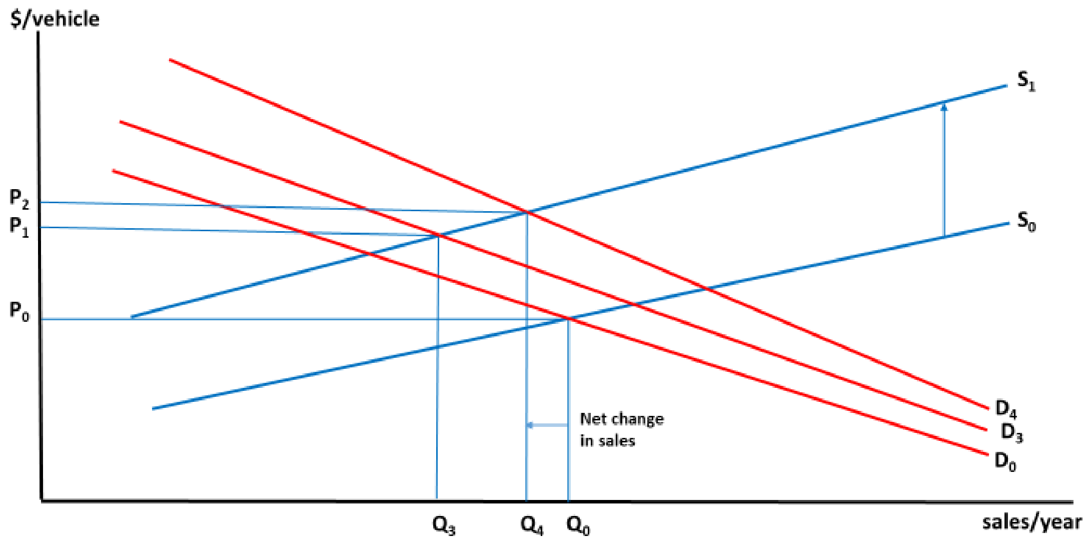
These indirect effects on the used vehicle market will occur in response to increased CAFE standards but will be reversed if the stringency of standards is reduced. Lower prices for new cars and light trucks will reduce demand for used models, lowering their market value and prompting some owners to retire older vehicles rather than making the repairs necessary to keep them in usable condition. The combination of increased sales of new models and faster retirement of the oldest vehicles in use will speed turnover of the fleet, shifting travel to new vehicles and away from older ones when compared to the baseline alternative and use of the reference fleet.

7.1.3. Longer Term Effects on New and Used Vehicle Markets

Because new and used vehicles can substitute for each other to meet households' and businesses' demands for transportation services, the change in used vehicle prices will have secondary effects in the markets for new cars and light trucks, as Figure 7-3 illustrates. Higher prices for used vehicles, despite having originally resulted from increased costs and prices for new models, will in turn increase demand for new models. This effect is shown in Figure 7-3 as a shift in demand for new vehicles outward from D_3, its last near-term position shown previously in Figure 7-1, to D_4 in Figure 7-3. In conjunction with the upward-shifted supply curve shown previously in Figure 7-1, which reflects manufacturers' increased costs to produce CAFE-compliant new cars and light trucks, this secondary increase in demand raises their prices slightly from their ultimate level P_1 in Figure 7-1, to P_2 in Figure 7-3.

At the same time, this further outward shift in the demand curve for new vehicles would partially mitigate the near-term decline in their sales. In Figure 7-3, new car and light truck sales ultimately settle at Q_4, a level higher than their near-term equilibrium level Q_3 shown previously in Figure 7-1, though still lower than their reference baseline level Q_0. Thus, the longer term effect of setting standards on sales of new vehicles is likely to be more modest than it would have been if new and used vehicles were not substitutable and there were no interactions between markets for the two. In contrast, the ultimate effect on prices for new vehicles may be larger than the immediate effect, though the secondary response to higher used car prices is likely to be modest compared to the primary effect from higher production costs, as Figure 7-3 suggests.

Figure 7-3: Longer Term Effects on Sales and Prices of New Vehicles



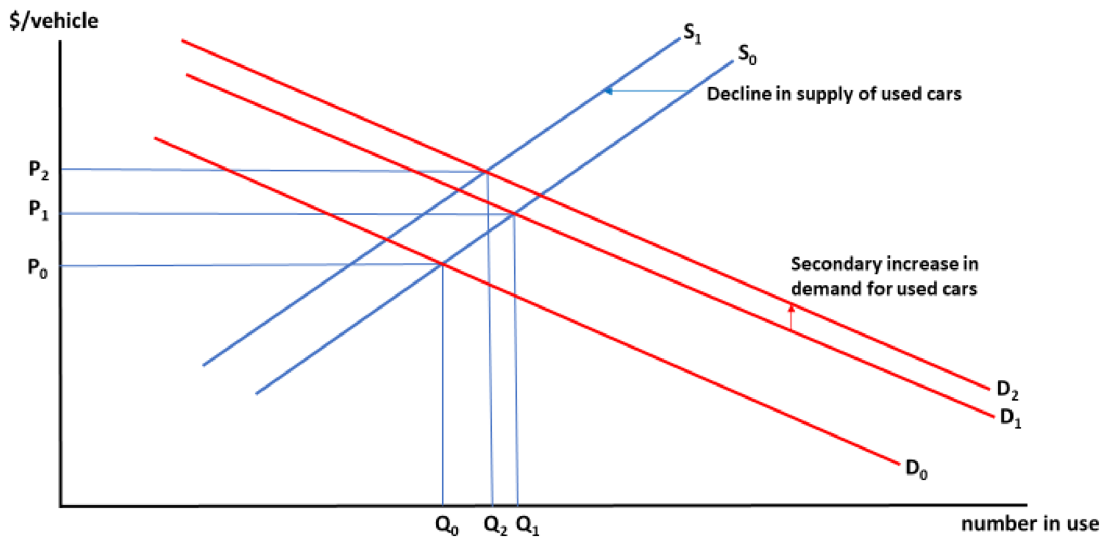
Finally, there are also likely to be important secondary impacts on the market for used vehicles. First, the secondary increase in prices for new vehicles will raise demand for their used counterparts further, again because—within limits imposed by evolution in their designs over time and the effects of accumulated use—the two can substitute for each other in providing transportation services. At the same time, the decline in sales of new vehicles during the current model year reduces the supply of used models available in future years, as fewer of the current year's newly produced models subsequently enter the used vehicle market. The resulting long-term reduction in the total supply of used vehicles of all ages will accumulate over time.

This occurs simply because fewer new cars are initially produced and sold during each model year subject to higher standards, so fewer remain in use at the outset of any subsequent calendar year and thus available to be maintained in (or restored to) working condition when their market values rise. While the effect of higher new-car prices on demand for used vehicles is likely to be felt within the current model year, the reduction in their supply resulting from lower new vehicle sales will accumulate more gradually over time.

Figure 7-4 illustrates these longer term effects. The secondary increase in prices for new vehicles increases demand for used cars further relative to the near-term effect of higher new car prices, shifting the demand curve further outward from its previous position at D_1 in Figure 7-2 to D_2 in Figure 7-4. At the same time, the reduction in sales of new models reduces the supply of used versions available in future years, and this effect—which accumulates over time, as noted above—is represented in Figure 7-4 as an inward shift in the supply curve for used vehicles, from S_0 to S_1. Increased demand and reduced supply of used vehicles interact to raise their average price further beyond its near-term increase to P_1, shown previously in Figure 7-2, to the higher level P_2 in Figure 7-4.

In response to this secondary increase in their market value, the number of used vehicles remaining in working condition adjusts further; depending on the relative magnitudes of the shifts in demand and supply, the ultimate equilibrium size of the used vehicle fleet can be larger or smaller than in the nearer term. Figure 7-4 illustrates the case where the effect of reduced supply outweighs that of increased demand and the number of used vehicles in service (Q_2) declines relative to the near term (Q_1). However, the more certain—and more impactful—effect is that the final equilibrium size of the used vehicle fleet (Q_2 in Figure 7-4) will be larger than it would have been if CAFE standards were not in place and instead remained at their reference baseline levels (Q_0).

Figure 7-4: Longer Term Effects on Prices for Used Vehicles and the Number Remaining in Use



In theory, these reciprocal responses of new-car and used-car demand to increasing prices for each other will continue until markets for the two jointly reach a new equilibrium, though in practice these further adjustments seem likely to "dampen out" relatively quickly. It is difficult to anticipate exactly how long these complex adjustments will continue, but most of the ultimate change in new vehicle prices and sales should be largely complete within the same model year when standards take effect. The complete effects on prices and sales of used vehicles shown in Figure 7-4 are likely to require considerably longer to be fully felt because, as indicated, they depend in part on the longer term cumulative effect of lower new vehicle sales on the supply of used models.[98]

As with the near-term effects on the used vehicle market, these indirect effects will accumulate if CAFE standards increase over successive model years but will ultimately be reversed if the stringency of standards is reduced. The secondary decline in prices for new cars and light trucks illustrated in Figure 7-3 will reduce demand for used models slightly further, while increased sales of new models will be reflected in a growing supply of used vehicles. These effects will combine to lower the market value of used cars and light trucks further, prompting still more of their owners to retire them from service. Together with increasing sales of new cars and light trucks, speeding retirement of the oldest vehicles will accelerate turnover of the entire light duty vehicle fleet, shifting travel from older vehicles to new ones as compared to the baseline alternative.

7.1.3.1. Estimating Impacts in the New and Used Vehicle Markets

NHTSA uses an econometric model that captures the historical relationship of new car and light truck sales to the number of U.S. households, disposable personal income, and other economic variables to project future sales of new vehicles under the reference baseline alternative.[99] To estimate the effect of increased costs to produce new vehicles and the resulting higher prices due to CAFE standards for future model years, NHTSA applies a price elasticity of new vehicle sales of -0.4, which implies, for example, that a 10-percent increase in new vehicles' average price causes a 4-percent decline in their total sales.[100]

The agency estimates the shares of future sales accounted for by cars and light trucks by incorporating EIA's fleet share projection in the reference baseline alternative and adjusting those reference baseline shares under each regulatory alternative it considers. Those adjustments are based on relative changes in regulatory costs for cars and light-trucks between the reference baseline and each regulatory alternative.[101] The development and use of these projections are described in detail in Chapter 4.2 of the Draft TSD accompanying this proposed rule.

To estimate the effects of new vehicle standards on the used vehicle fleet, NHTSA uses a detailed econometric model relating prices, fuel economy, and other characteristics of new vehicles to age-specific retirement rates for each vintage of used vehicles making up the current year's fleet. This model also controls for the increasing durability of new vehicles over time, fuel prices, macroeconomic conditions, and other factors that influence year-to-year variation in used vehicles' retirement rates. The development and use of this model is described in Chapter 4.2.2 of the Draft TSD accompanying this proposed rule.

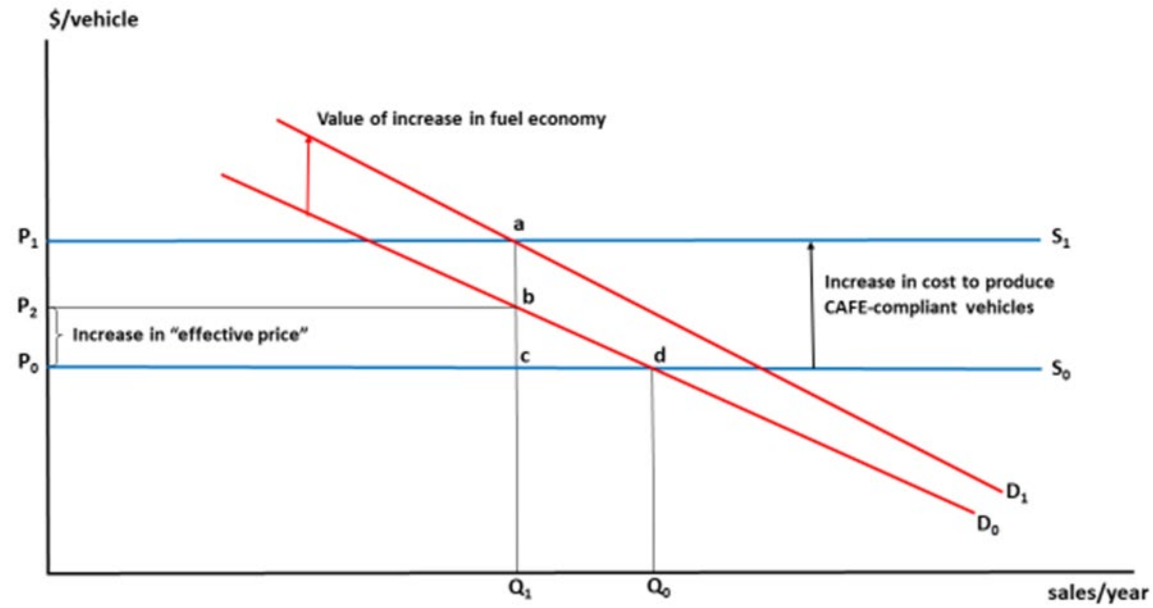
7.1.4. Welfare Effects in the New and Used Vehicle Markets

The likely decline in sales of new vehicles during future model years when higher CAFE standards take effect produces two potential sources of economic costs. Figure 7-5 illustrates these costs for the simplified case where demand for new vehicles increases (from D_0 to D_1) as their manufacturers improve fuel economy to comply with stricter standards but make no accompanying sacrifices in their models' other attributes.[102] As in Figure 7-1 and Figure 7-3 above, the new demand curve D_1 reflects potential buyers' valuation of the improved fuel economy that CAFE standards require, and D_1 converges toward D_0 moving to the right because each successive additional buyer has a slightly lower value of the resulting fuel savings than the

[98] For more information on this effect, see Jacobsen et al., The Effects of New-Vehicle Price Changes on New- and Used-Vehicle Markets and Scrappage, EPA-420-R-21-019, EPA: Washington, DC (2021), available at: https://cfpub.epa.gov/si/si_public_record_Report.cfm?Lab=OTAQ&dirEntryId=352754 (accessed: Sept. 10, 2025) (hereinafter, "Jacobsen et al. (2021)").
[99] Projected total sales are adjusted to include only gas powered vehicles using the 2025 EIA's projection of gas powered market share in each future model year.
[100] This estimate is drawn from Jacobsen et al. (2021), Chapter 7.
[101] Fleet shares are projected and adjusted using the current classification of models. In model years and alternatives in which reclassification is considered this remains the case, though when reporting the regulatory class sales, costs, and effects, values are totaled by regulatory class using the proposed alternative classification.
[102] This example provides a conservative estimate of costs because if manufacturers forgo any improvements in vehicles' other features as part of their effort to increase fuel economy, the decline in sales will be larger than Figure 7-5 shows, as the discussion accompanying Figure 7-1 above indicated. On the other hand, the assumption of "perfectly elastic" supply (indicated by the horizontal supply curve shown in the figure) may slightly exaggerate the increase in prices. Under the perhaps more realistic assumption of less than perfectly elastic supply of new vehicles, manufacturers would absorb some of their increased costs to meet CAFE standards, so the increase in prices and resulting decline in sales would be slightly smaller than Figure 7-5 shows. Of course, in that case there also would be a reduction in producer surplus, which represents a welfare loss to manufacturers and those owning a financial interest in them. The sum of losses in consumer and producer surplus with varying elasticities of supply is likely to be comparable to the loss in consumer surplus in the "perfect elasticity" case shown in Figure 7-5.

previous buyer. Though the upward shift in the demand curve in response to improved fuel economy by itself would raise sales, prices rise from P_0 to P_1 as producers attempt to recoup their higher costs for producing vehicles that meet the new standard and suppress sales by more than enough to offset this gain. On balance, sales of new cars and light trucks thus decline to Q_1, where the "last" buyer is willing to pay exactly the higher price manufacturers charge for a car or light truck that meets the new standard.

Figure 7-5: Welfare Effects in the Market for New Vehicles



Though buyers who continue to purchase new vehicles—even at their increased price—are likely to be those with the highest valuation of improved fuel economy, they nevertheless experience some loss in welfare from the combination of higher prices and improved fuel economy. Buyers' net loss in welfare is measured by their increased outlays to purchase Q_1 new vehicles, shown as rectangle P_1-a-c-P_0 in Figure 7-5 (its area is the increase in price multiplied by the number that continue to be sold), minus the value they attach to the savings in fuel costs that result from higher fuel economy. The total value of their savings in fuel costs is the smaller rectangle P_1-a-b-P_2, the area of which equals the marginal buyer's valuation of the improvement in fuel economy (the distance ab, or the upward shift in the demand curve at sales level Q_1) multiplied by the number of new vehicles that continue to be sold (Q_1). Together, these partly offsetting impacts leave net losses to continuing buyers equal to rectangle P_2-b-c-P_0.[103]

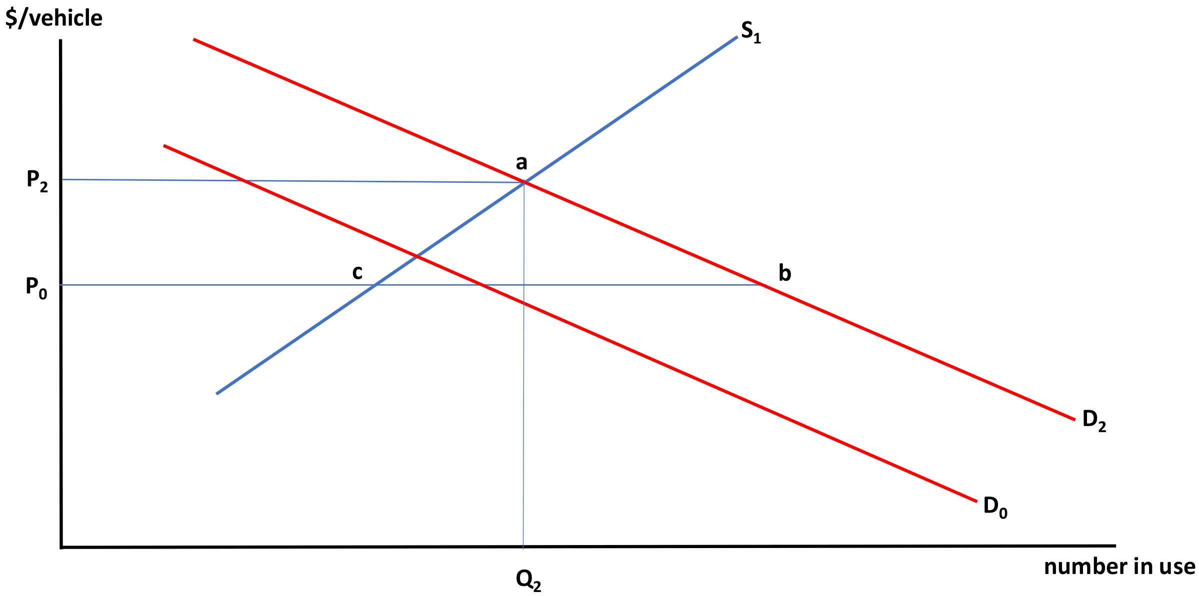
Some buyers who would have purchased new vehicles absent regulation will decide not to do so once CAFE standards take effect and cause their prices to rise because they have lower values of the fuel savings that cars and light trucks meeting the new standard offer, and higher prices reduce the number sold from Q_0 to Q_1.[104] The welfare loss to former buyers who are "deterred" by new vehicles' higher "effective price" is calculated as $½*(Q_0-Q_1)*(P_2-P_0)$, the area of triangle b-c-d in Figure 7-5, in keeping with standard economic practice.

The consequences of adopting standards for economic welfare are more complex in the used vehicle market. Higher prices for used vehicles result in a loss of consumer surplus to their potential buyers, which is shown in Figure 7-6 below (a simplified version of the previous Figure 7-4, omitting the initial supply curve S_0 and the intermediate demand curve D_1 shown in Figure 7-4) as the area P_2-a-b-P_0. However, much of this loss is simply a transfer to suppliers of used cars and light trucks who are a combination of retail dealers and

[103] Another way to view this result is that the "effective price" of new vehicles—the difference between the actual increase in their price and the increase in their value due to their higher fuel economy—increases only from P_0 to P_2, so the loss to "continuing" buyers is equal to the product of this effective price increase and the number of vehicles that continue to be sold, which again is rectangle P_2bcP_0.
[104] Their valuation of the required increase in fuel economy ranges from slightly to significantly below that of continuing buyers, as the convergence between demand curves D_1 and D_0 suggests.

individual owners selling used vehicles on the private market. Collectively, used vehicle owners experience a gain equal to area P_2-a-c-P_0 in Figure 7-6, which offsets much of the loss in consumer surplus to buyers; the remaining uncompensated loss in consumer surplus is the smaller triangle a-b-c. Estimating the value of this loss would require detailed data on prices for used cars and light trucks of different ages, together with estimates of both the elasticity of their supply (which also would be expected to vary with age) and the “cross-elasticities” of demand for used cars and light trucks of varying ages with respect to the prices of new models. Because the agency lacks such detailed information, it has not attempted to estimate the dollar magnitude of this effect.

Figure 7-6: Welfare Effects in the Market for Used Vehicles



As discussed previously, however, the increase in used vehicle prices that creates these welfare effects in the used vehicle market also causes a secondary increase in demand for new cars and light trucks, shown previously as the longer run upward shift of the new-car demand curve to position D_4 in Figure 7-3. This secondary increase in new-car demand acts much like the improvement in new cars’ fuel economy, by limiting the decline in their sales and the accompanying loss in consumer surplus to their would-be buyers. Under reasonable assumptions, this reduction in the welfare loss to new vehicle buyers will approximately offset the net loss in welfare in the market for used vehicles.[105] Hence the agency’s analysis omits both effects, since including them would have little net effect on the comparison of total costs and benefits from imposing CAFE standards.

7.1.5. Safety Implications of Fleet Turnover

As manufacturers introduce new vehicles into the market, they typically incorporate new safety technologies and designs that make the new vehicles safer than previous models for both their occupants and those of other vehicles using the road. The increased application of Advanced Driver Assistance Systems (ADAS) technologies is a key example of this trend. Regulations also affect the safety of new vehicles. For example,

[105] Boardman A. et al., Cost-Benefit Analysis: Concepts and Practice, 2nd ed., Prentice Hall Inc.: Upper Saddle River, NJ (2001), available at: https://www.researchgate.net/publication/307968974_Cost-Benefit_Analysis_Concepts_and_Practice_2nd_edition (accessed: Sept. 10, 2025); Mohring, H., Maximizing, Measuring, and Not Double-Counting Transportation Improvement Benefits: A Primer on Closed- and Open-Economy Cost-Benefit Analysis, Chapter 5, *Transportation Research*, Vol. 27(6): pp. 413 – 24 (1993), available at: https://www.sciencedirect.com/science/article/abs/pii/0191261593900142 (accessed: Sept. 10, 2025).

NHTSA recently issued a final rule requiring both Automatic Emergency Braking (AEB) and Pedestrian Automatic Emergency in light vehicles[106] and a proposed rule that would require AEB in heavy vehicles.[107,108]

The CAFE Model simulates how manufacturers respond to different standards and how more stringent standards require them to employ additional technologies to ensure their vehicles comply. The application of these technologies increases the cost of new vehicles to consumers, and as indicated above, the resulting combination of higher sales prices and fuel economy causes some consumers to defer or forgo purchasing a new vehicle. These consumers might purchase a used vehicle or opt to continue driving their current vehicle instead, but these older vehicles lack the safety features of newer models and thus have higher crash risks. More stringent CAFE standards slow the normal turnover and renewal of the vehicle fleet, increasing the prevalence of older vehicles and vehicles without new safety technologies in the fleet and in turn affecting the number and severity of crashes that occur. In contrast, reducing the stringency of CAFE standards will accelerate turnover of the vehicle fleet and the replacement of older cars and light trucks with newer models, and the increased prevalence of vehicles equipped with advanced safety features will reduce the frequency and severity of crashes slightly.

Manufacturers' efforts to comply with CAFE standards may also lead to changes in vehicle mass, which affects the prevalence of injuries and fatalities on roadways. By changing the relative prices of new vehicles, the standards also impact the market shares of cars and light trucks, leading to differences in the number of heavier and lighter new vehicles on the road. Increases in vehicle mass might confer additional safety to vehicle occupants while also reducing safety for pedestrians, cyclists, and other vulnerable road users, as well as for road users with lower mass vehicles. Reductions in mass, which are one way of achieving higher fuel efficiency, could have the opposite effect. Chapter 8 of the Draft TSD explains NHTSA's methodology for estimating the safety implications of CAFE standards in detail.

7.2. The Effect of Standards on Vehicle Use

The fuel economy rebound effect refers to the tendency of motor vehicles' use to increase when their fuel economy is improved and the cost of driving each mile declines as a result. When CAFE standards compel higher fuel economy levels for new cars and light trucks, the amount of fuel they consume per mile is reduced and the resulting decline in the cost to drive each mile leads to an increase in the number of miles they are driven over their lifetimes. For its analysis of this proposed rule, NHTSA uses a value of 15 percent for the fuel economy rebound effect, which implies that a 10-percent increase in new vehicles' fuel economy will produce a 1.5-percent increase in the number of miles they are driven annually throughout their lifetimes. For more discussion of the fuel economy rebound effect and a description of the agency's method for deriving its empirical estimate, see Draft TSD Chapter 4.3.5.

7.2.1. The Fuel Economy Rebound Effect and Vehicle Use

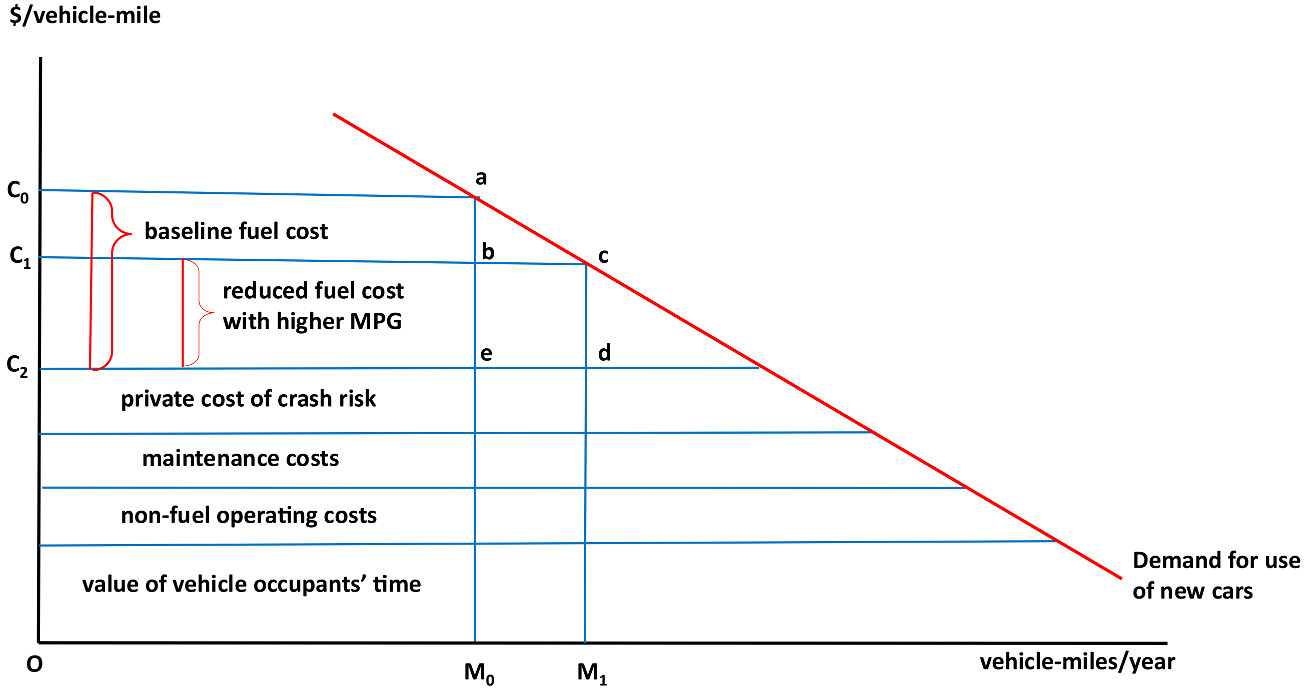
Figure 7-7 illustrates the effect of requiring new vehicles to achieve higher fuel economy on the number of miles they are driven annually. As the figure shows, vehicles' per-mile operating costs include the cost of fuel they consume, operating costs other than fuel (e.g., oil or tire wear), maintenance and repair outlays, the expected cost associated with potential crashes, and the value of their occupants' travel time. The figure's vertical axis measures cost per mile driven, and C_2 represents the per-mile cost of driving, excluding fuel costs. Cost C_0 adds fuel costs to measure the initial total cost of driving each mile, while C_1 shows the lower per-mile total cost of driving new vehicles with CAFE standards in effect.

Requiring new vehicles to achieve higher fuel economy reduces the amount of fuel they consume each mile and lowers their per-mile fuel cost from (C_0-C_2) to (C_1-C_2), thus reducing the total cost of driving each mile from C_0 to C_1. If the use of new cars and light trucks remained unchanged, their owners' total savings in fuel costs would be the rectangle C_0-a-b-C_1, the area of which is the product of the reduction in per-mile fuel costs and the number of miles driven. However, the decline in their driving costs leads to a downward movement

[106] NHTSA, Federal Motor Vehicle Safety Standards; Automatic Emergency Braking Systems for Light Vehicles, 89 FR 39686 (May 9, 2024).
[107] NHTSA and the Federal Motor Carrier Safety Administration (FMCSA), Automatic Emergency Braking Test Devices: Heavy Vehicle Automatic Emergency Braking, 88 FR 43174 (July 6, 2023).
[108] Please see the current Unified Agenda of Regulatory and Deregulatory Actions, available at https://www.reginfo.gov/public/, for the latest information on NHTSA rulemakings related to AEB systems in light vehicles and heavy vehicles.

along the demand curve for vehicle use, increasing the average number of miles that buyers of new cars and light trucks drive annually from M_0 to M_1.

Figure 7-7: Effect of Increasing CAFE Standards on New Vehicle Use



While this increase in driving offsets a small fraction of the fuel savings that would otherwise result, it also creates additional economic benefits (as well as a variety of indirect economic benefits and costs, which are discussed in subsequent chapters). Most importantly, vehicle buyers' annual outlays for fuel will still be lower throughout the lifetimes of the models they purchase, as standards lead to higher fuel economy levels and reduced fuel consumption. The magnitude of this benefit depends on how much new vehicles' fuel economy increases when future standards are raised, how much they are driven each year, and future retail prices for fuel. The total amount of rebound driving for the fleet as a whole depends on its overall age composition and fuel efficiency. Higher standards lower new vehicle sales and slow fleet turnover, which dampens the fleetwide rebound effect, as relatively inefficient used vehicles represent a greater share of the fleet.

During the year they are initially sold, new vehicle fuel cost savings are measured by the difference between the cost of fuel consumed by the additional driving (area b-c-d-e) and the savings in fuel costs on the amount of driving that would have been done under the baseline (area C_0-a-b-C_1). Though Figure 7-7 is drawn to emphasize the reduction in fuel costs and the resulting increase in driving and thus makes it appear otherwise, area C_0-a-b-C_1 will be much larger than area b-c-d-e when calculated using the parameters applied in this analysis. Thus, the difference between them will be negative, indicating that on balance there will be a large net savings in total fuel consumption and costs.

The agency estimates the savings in new vehicles' annual fuel costs using improvements in the fuel economy of individual car and light truck models projected to result from setting CAFE standards, estimates of how much they will be used with and without the increased driving due to the rebound effect of higher fuel economy, and projections of fuel prices from the EIA's AEO 2025. As indicated above, this savings declines over vehicles' lifetimes as they are driven progressively less and gradually retired from use, though their future annual use also varies in response to projection changes in fuel prices. The savings in fuel costs for a new vehicle produced during each future model year required to meet CAFE standards will equal this same area during the year it is initially sold and decline similarly over its lifetime in the fleet.

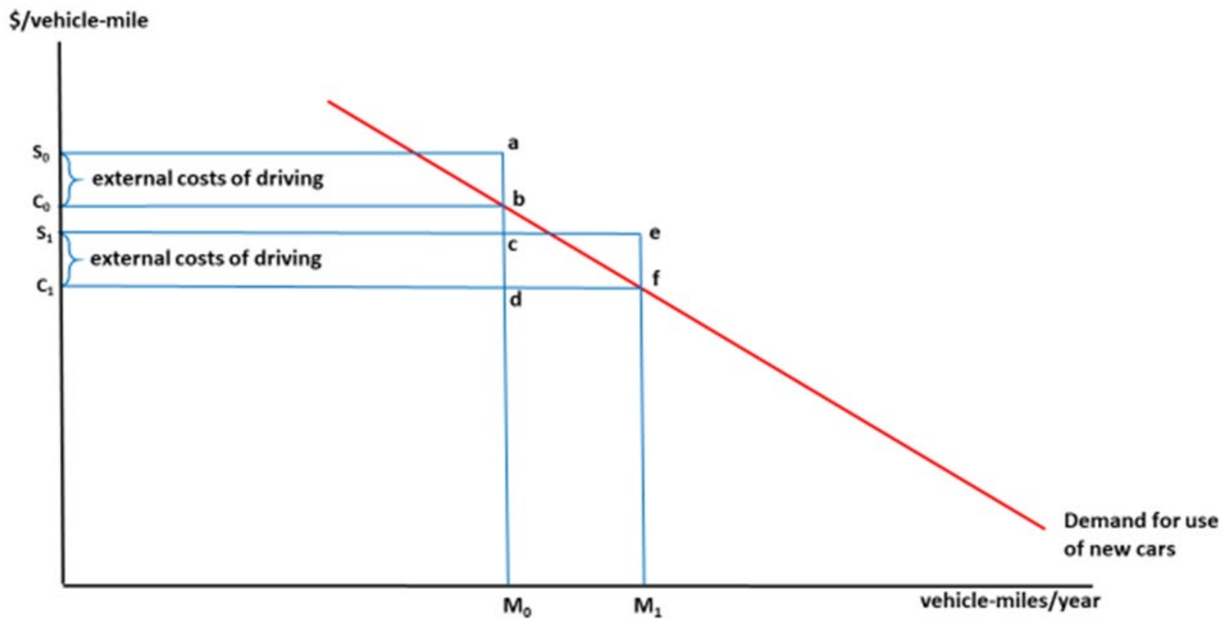
Second, the additional mobility associated with increased driving provides some benefits to new vehicle buyers. These benefits must be more than sufficient to offset the costs of their additional driving, including expenses for fuel, vehicle depreciation, other operating costs, maintenance, the value of travel time, and the increased safety risks they assume; if they were not, no additional driving would occur. In Figure 7-7, mobility benefits from increased driving are equal to the area M_0-a-c-M_1, which exceeds the total cost of the additional driving, measured by area M_0-b-c-M_1. The amount by which these mobility benefits exceed the costs of additional travel, shown as the triangular area a-b-c in Figure 7-7, measures the net benefit (or gain in consumer surplus) to buyers of new vehicles from their additional driving. Following the usual procedure, the dollar value of this welfare gain is estimated as one-half of the product of the decline in driving costs ($C_0 – C_1$) and the resulting increase in vehicle use ($M_1 – M_0$).

7.2.2. Externalities from Increased Rebound-Effect Driving

Vehicle use generates external costs via traffic congestion and roadway noise, exposure to accident risks, and adverse health effects from air pollution. The increase in driving by buyers of new vehicles in response to their improved fuel economy can offset some of the health benefits from lower fuel consumption and emissions, while also increasing traffic congestion and roadway noise. Though setting fuel economy standards will *on balance* reduce adverse health effects from air pollution, the increases in these external costs caused by added rebound-effect driving represent additional costs of setting higher fuel economy targets that must be accounted for alongside their benefits.

Figure 7-8 illustrates how NHTSA estimates these costs; like the preceding figure, it shows the demand for travel using new vehicles and illustrates the effect of the reduction in per-mile driving costs on their increased use that occurs when their fuel economy improves. For simplicity, however, Figure 7-8 omits the detailed breakdown of total driving costs shown in the previous figure, and instead shows the combined external costs imposed by new vehicles' contributions to traffic congestion, road noise, injuries and property damage from crashes, and air pollution.

Figure 7-8: Externalities Caused by Increasing Use of New Vehicles



As in Figure 7-7, Figure 7-8 denotes private costs as C_0 prior to an increase in fuel economy and C_1 after an improvement in fuel economy; per-mile external costs are added to these to estimate the total social costs associated with each mile driven, denoted S_0 and S_1. At the initial level of new vehicle use, these external costs are equal to the product of their per-mile value (shown as the distance $S_0 – C_0$ in Figure 7-8) and the initial level of vehicle use M_0, or the rectangular area S_0-a-b-C_0. With the increased driving that occurs when fuel economy increases (M_1 in Figure 7-8), the total cost of these externalities is again the product of their per-mile value ($S_1 – C_1$) and this higher level of use M_1, or the rectangular area S_1-e-f-C_1.

If the per-mile value of these externalities is unaffected by the increase in new vehicles' use that occurs in response to improved fuel economy, as the figure illustrates (that is, the distances $S_1 – C_1$ and $S_0 – C_0$ are equal) and the agency's analysis assumes, total external costs will increase by the area of the rectangle c-e-f-d, which is equal to the increase in the number of miles driven ($M_1 – M_0$), multiplied by the per-mile value of external costs ($S_1 – C_1$). In other words, this additional cost is the difference between the total cost of driving-related externalities caused by new cars and light trucks with higher fuel economy, and the value of those costs if the reference baseline standards had remained in effect. It is a direct consequence of the additional driving estimated to result from the fuel economy rebound effect. Reducing the stringency of CAFE standards from their baseline level would produce exactly the opposite effects, reducing the use of new cars and light trucks slightly and mitigating their contributions to congestion, noise, and emissions.

The agency's analysis separately calculates the changes in each of these external costs resulting from more intensive use of new cars and light trucks. Changes in emissions of criteria air pollutants are calculated from the increase or reduction in the number of miles new cars and light trucks are driven, together with per-mile emission factors for future model year vehicles derived from EPA's Motor Vehicle Emission Simulator (MOVES5) model. Per-mile costs of congestion and road noise are estimated using incremental per-mile contributions of car and light truck use to delays and noise originally estimated by Federal Highway Administration of the DOT and updated by NHTSA for this analysis. Finally, the agency assumes that drivers consider only 90 percent of the added risk of injuries and property damage in crashes they impose when they elect to travel more, so 10 percent of the increase in these costs also represents an external cost of added rebound-effect driving.

7.3. Effects of CAFE Standards on Fuel Consumption

Resetting CAFE standards to require lower fuel economy for new cars and light trucks will increase U.S. demand for transportation fuels and, since petroleum-based gasoline and diesel account for most of the energy they consume, U.S. demand for petroleum will also increase. In recent decades, domestic gasoline consumption has declined, while production has mostly continued to grow. As documented in Draft TSD Chapter 6.2.4.5, this domestic decline has led to increased U.S. exports of refined fuel, so NHTSA expects that future changes in fuel consumption caused by adjusting CAFE standards will mostly be reflected in the trade of gasoline rather than in domestic petroleum production or fuel refining.

Extracting and transporting crude petroleum, refining it into fuel, and distributing fuel for retail sale produce additional emissions of criteria air pollutants beyond those from vehicles' consumption of fuel, so any reduction in domestic fuel consumption will generate additional benefits by reducing the health damages those emissions cause. Higher standards will also cause slower fleet turnover, which mitigates some of the benefits associated with reductions in fuel consumption by keeping less efficient vehicles on the road longer. Reduced spending on fuel by drivers of new vehicles will also lower tax revenues to both Federal and state governments, which typically fund spending on transportation infrastructure or other programs, thus reducing the benefits those programs provide, which will offset part of those drivers' savings in retail outlays for fuel.

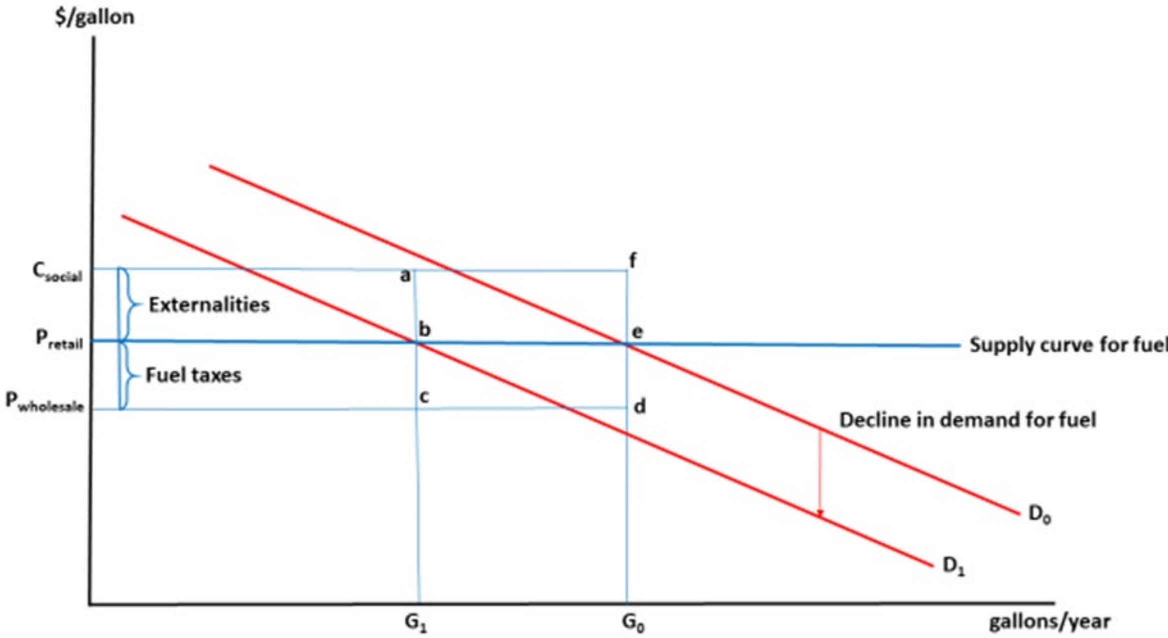
7.3.1. Impacts on Fuel Use and Spending

Increasing CAFE standards reduces U.S. demand for petroleum-based transportation fuels, shown in Figure 7-9 as an inward shift in the U.S. demand curve for fuel from D_0 to D_1. Vehicles subject to the higher standards will save fuel throughout their lifetimes, and while added rebound-effect driving and the shift of some driving to used cars will partly offset these savings, on balance domestic demand for fuel will decline. The global supply of refined transportation fuels appears to be extremely "price-elastic"—that is, increasing production does not require significantly higher cost extraction or refining at the margin—so reducing domestic demand is not expected to lower fuel prices, as the figure indicates.[109] Because of lower demand,

[109] This is admittedly a simplification, as the domestic fuel supply curve is likely to slope upward slightly, so prices will decline very slightly in response to lower U.S. demand when CAFE standards are raised and will increase slightly if domestic gasoline demand rises in response to lower standards. Nevertheless, NHTSA believes the analysis presented in Figure 7-9 is likely to represent a close approximation to the effects of changing CAFE standards on the domestic gasoline market.

domestic fuel consumption will decline from G_0 to G_1 in Figure 7-9, and U.S. drivers' spending on fuel will be reduced by the rectangular area G_1-b-e-G_0. The dollar value of this area is equal to the retail price of fuel per gallon, labeled P_{retail} in the figure, multiplied by the decline in the number of gallons consumed, or $G_0 - G_1$.

Figure 7-9: Effect of Increasing CAFE Standards on Fuel Consumption and Spending



NHTSA's analysis measures savings in fuel spending by the owners of cars and light trucks using retail fuel prices, which include a significant tax component—Federal, state, tribal, and some local governments impose taxes on gasoline and diesel that together average approximately $0.57 per gallon. Thus, some fraction of drivers' savings in fuel costs—shown as the rectangle b-e-d-c in Figure 7-9—represents lower tax payments; their yearly dollar value is the product of average fuel taxes per gallon ($P_{retail} - P_{wholesale}$) and the decline in the number of gallons consumed annually ($G_0 - G_1$). However, the loss in public benefits from marginally lower spending on programs funded from fuel tax revenue should be almost exactly offset by the part of drivers' savings in retail fuel costs that represents lower fuel tax payments, so on balance this revenue transfer leaves net social benefits unchanged by a change in fuel economy standards.

7.3.2. Externalities from Refining and Consuming Fuel

Extracting and transporting crude petroleum, refining it to produce transportation fuels, and distributing fuel generate additional emissions beyond those from vehicles' use of petroleum-derived fuels. By changing the volume of fuel produced and consumed, adopting CAFE standards affects localized health damages caused by exposure to criteria air pollutants. Because they are felt broadly across the United States, changes in these emissions will affect the agency's estimates of external costs and benefits from changing the standards.

In Figure 7-9, the economic cost of health damage externalities is shown as the difference between the social cost of supplying fuel C_{social} and its retail price P_{retail}, and these costs are assumed to be constant on a per-gallon basis. In the case of setting the standards, the reduction in economic costs of health damages resulting from lower fuel consumption is thus the rectangular area a-f-e-b in the figure, which is equal to the product of their per-gallon value and the reduction in the number of gallons of fuel supplied and consumed. In turn, benefits from reduced health impacts stem from lower domestic emissions of criteria air pollutants.[110] Some of these benefits are eroded by increased rebound driving and fuel consumption, as well as the effect of high standards on fleet turnover.

[110] Following guidance in OMB Circular A-4, NHTSA's analysis includes the value of reductions in domestic health damages resulting from the U.S. population's exposure to criteria air pollutants.

The agency's evaluation also accounts for changes in benefits from changes in domestic emissions of criteria air pollutants that occur during fuel refining and distribution, again using emission rates for different fuels derived from Argonne's Greenhouse gases, Regulated Emissions, and Energy use in Transportation (GREET) Model. Health damage costs resulting from increased population exposure to harmful accumulations of criteria pollutants were obtained from recent EPA analyses. These costs differ between vehicle and "upstream" emissions (from petroleum production, refining, and fuel distribution), reflecting differences in their geographic dispersal, accumulation, and resulting population exposure. Detailed descriptions of the sources used to develop these inputs appear in Chapter 6.2.1 of the Draft TSD.

7.3.3. Effects on Petroleum Consumption and U.S. Energy Security

Changing U.S. fuel and petroleum consumption via CAFE standards affects the exposure of U.S. consumers to the disruptive impacts of sudden increases in oil prices. If households and businesses that use petroleum products do not directly bear all the costs of adjusting to rapid price increases (that is, if they are partly "external" to petroleum consumers), reducing their consumption could provide additional benefits to the U.S. economy beyond simply reducing spending on petroleum products. This effect is usually referred to as an "energy security externality" caused by U.S. petroleum consumption and imports, and reducing each of them is often cited as a potential economic benefit of lowering U.S. oil demand.

Chapter 6.2.4 of the Draft TSD assesses the extent to which changing domestic gasoline use will directly affect domestic petroleum consumption and U.S. energy security, discusses whether doing so actually represents a real economic benefit, and describes how this benefit could be measured. This effect has diminished in recent decades but not totally disappeared, as the U.S. economy has become less energy intensive, and thus less sensitive to oil price shocks. NHTSA's analysis of changing CAFE standards includes estimated changes in the external costs of petroleum consumption as a measure of U.S. energy security.

8. Effects of Regulatory Alternatives

CAFE Model Files Referenced in this Chapter

Below is a list of CAFE Model Files referenced in this chapter. See Draft TSD Chapter 2.1.9 "Where to Find the Internal NHTSA Files" for a full list of files referenced in this document and their respective file locations.

- CAFE Model Documentation
- Parameters Input File
- CAFE Model Output File

Fuel economy standards produce wide-ranging effects in the vehicle market, society, and the environment. NHTSA considers such effects when making decisions about fuel economy standards. This proposed rule considers several regulatory alternatives for vehicles in MYs 2027-2031 and presents estimated impacts from these alternatives. The CAFE Model explicitly estimates manufacturers' responses to each set of alternatives in each fleet and quantifies numerous effects of these alternatives throughout the lifetimes of vehicles in the fleets. The analysis supporting this proposed rule should be interpreted not as a forecast, but rather as an assessment of impacts that could occur, reflecting NHTSA's best judgments regarding different and often uncertain factors. The analysis is conducted subject to a set of constraints as outlined in EPCA/EISA. Those constraints include the prohibition of considering the fuel economy of dedicated alternative fuel vehicles when determining maximum feasible standards and limitations on the transfer and use of compliance credits. These constraints were applied in the central analysis discussed in this chapter. In addition to the results of the central analysis discussed below, the agency has conducted a sensitivity analysis to assess a variety of potential changes in key analytical inputs (e.g., fuel prices, macroeconomic forecasts, or technology assumptions). The sensitivity analysis is presented in Chapter 9 of this PRIA.

This chapter describes the effects of each of the three alternatives in relation to a No-Action Alternative, which is described in detail in Chapter 3. The discussion in this chapter is split into parts based on the effects that amending the standards would have on (1) vehicle manufacturers, (2) new vehicle buyers, (3) society as a whole, and (4) the physical environment. Effects on vehicle manufacturers include compliance outcomes (e.g., achieved average fuel economy and fuel efficiency levels), technology application choices, costs associated with technology adoption and compliance, and changes to sales and sector employment. New car and truck buyer impacts include vehicle price changes, fuel savings, and other mobility-related benefits (i.e., consumer benefits from travel due to changing expenditure on fuel). The impacts on society include effects that accrue to vehicle purchasers and non-purchasers alike. Examples of social impacts include the monetized value of changes in criteria pollutants, congestion, road noise, energy security consequences, and safety-related outcomes. Additionally, the proposed rule would affect the physical environment by altering overall vehicle use (e.g., VMT) and fuel consumption, which, in turn, affect criteria pollutant and toxic air pollutant emissions.

As discussed in the Draft TSD, the CAFE Model explicitly accounts for each model year from MY 1985 to MY 2050, simulating fleet turnover and mileage accumulation until all these vehicles are projected to have been scrapped (i.e., through CY 2089, when the last of the MY 2050 vehicles are projected to be in service). This analysis of the proposed rule presents impacts for each model year between MYs 2027-2031. Therefore, many impacts are most meaningfully understood by considering the vehicles produced in those *model years*. On the other hand, an understanding of the rule's physical impacts over time can also be important in some contexts. Accordingly, this analysis presents most physical impacts on a *calendar-year* basis—that is, showing projected total or incremental quantities through CY 2050, accounting for all vehicles projected in service in each calendar year (including vehicles produced during MYs 2032-2050).

The underlying CAFE Model Output Files are available on NHTSA's website.[111] A comprehensive appendix of detailed tables (e.g., results by manufacturer) are available in Appendix I. NHTSA is aware that alternative approaches based on revealed preference have been used to estimate the implicit compliance cost of similar

[111] NHTSA, CAFE Compliance and Effects Modeling System: The Volpe Model, Last revised: 2024, available at: https://www.nhtsa.gov/corporate-average-fuel-economy/cafe-compliance-and-effects-modeling-system (accessed: Sept. 10, 2025).

vehicle regulations.[112] The agency includes an analysis using a revealed preference approach in the accompanying PRIA Appendix II.

An additional and more detailed analysis of the environmental impacts of the regulatory alternatives is provided for in the accompanying Draft EIS. The results presented in this PRIA differ slightly from those presented in the Draft EIS. While EPCA/EISA requires that the Secretary (by delegation, NHTSA) determine the maximum feasible levels of CAFE standards in a manner that, as presented here, does not consider the factors prohibited by 49 U.S.C. 32902(h), NEPA does not impose such constraints on analysis presented in corresponding EISs, and the Draft EIS presents results of an “unconstrained” analysis that considers the prohibited factors.

Throughout this chapter, figures and tables report outcomes for a 3-percent and 7-percent discount rate, as directed by OMB Circular A-4. Unless otherwise noted, the compliance simulation is limited to all model years up to MY 2031; for tables and figures in this chapter, costs and benefits of the regulatory alternatives are reported in 2024 dollars and are associated with MYs 1985-2031 under the model-year perspective unless otherwise noted, and CYs 2024-2050 under the calendar-year perspective.

This chapter proceeds by summarizing costs and benefits of the regulatory alternatives relative to the No-Action Alternative. It then examines modeled compliance outcomes before exploring each of the above-mentioned impact categories in detail.

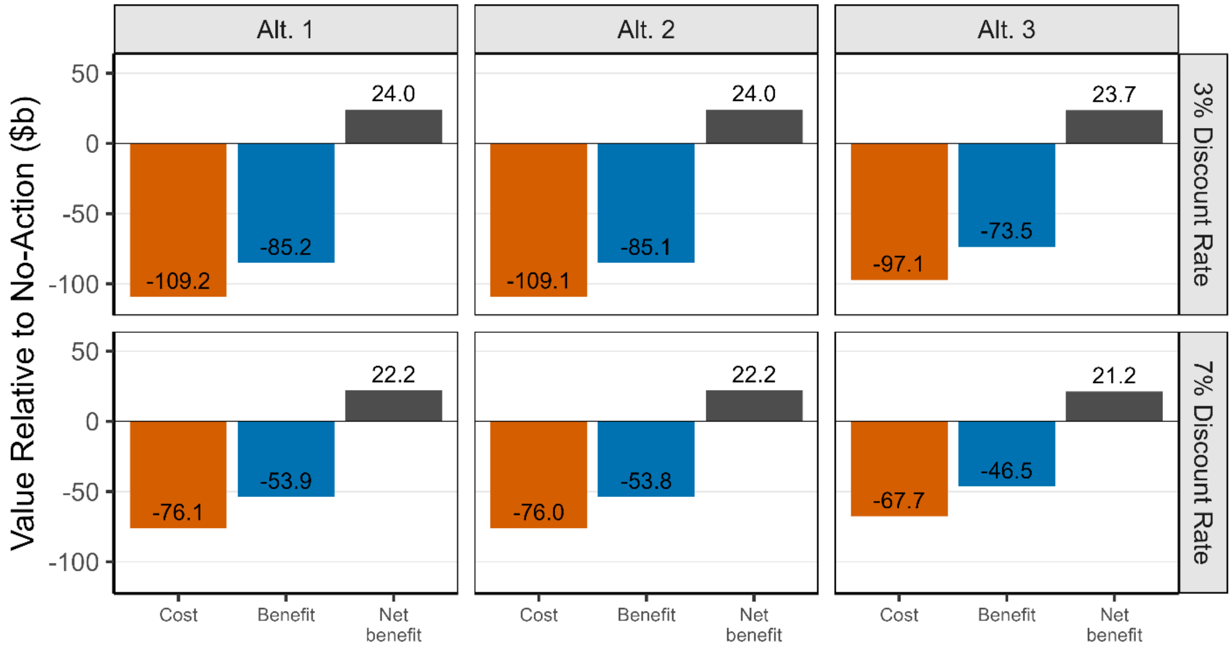
8.1. Summary of Benefits and Costs

To assess the effect of the regulatory alternatives, NHTSA aggregates outputs of the CAFE Model and compares the resulting cost and benefit values for each simulated alternative to those of the No-Action Alternative. Figure 8-1 presents the outcome of this calculation for MYs 1985-2031 at both a 3- and a 7-percent discount rate.[113] Costs and benefits increase across alternatives, corresponding with the stringency rates between Alternatives 1 and 3. Note that negative costs in Figure 8-1 denote a cost savings. Relative to the No-Action Alternative, program net benefits are positive across all alternatives.

[112] EPA, Reconsideration of 2009 Endangerment Finding and Greenhouse Gas Vehicle Standards, Draft Regulatory Impact Analysis, Appendix B (2025), available at: https://www.epa.gov/system/files/documents/2025-07/420d25003.pdf (accessed: Sept. 10, 2025).

[113] The reporting includes vehicles as far back as MY 1985 because new CAFE standards can affect any vehicle in the on-road fleet. As one example, higher costs for new vehicles may lower their sales and shift VMT to older vehicles, with consequent effects on fuel consumed and pollution rates. After 40 years, fewer than 2 percent of initial sales of a given model year tend to remain on the road. Therefore, NHTSA assumes that vehicles of a given model year vintage may still be on the road for up to 40 years, and any remaining vehicles after that point are assumed to be scrapped.

Figure 8-1: Costs and Benefits for the LD Vehicle Fleet, MYs 1985-2031



Chapter 8.4 outlines the main categories of costs and benefits aggregated to produce Figure 8-1. The largest component of these estimated costs is the technology cost savings for manufacturers to meet the CAFE targets under each alternative, while forgone fuel cost savings for consumers of new vehicles is the largest component in the benefits category.

8.2. Effects on Vehicle Manufacturers

To analyze how NHTSA's proposed revision of the CAFE standards impacts manufacturers, NHTSA starts by using the CAFE Model to simulate compliance pathways for manufacturers. These compliance pathways simulate how manufacturers could adopt technology to comply with the standards. NHTSA then evaluates the results of the compliance simulation, looking at manufacturers' compliance with the standards under various regulatory alternatives and estimating the impacts on vehicle cost and sales on employment.

8.2.1. Compliance Simulation

The CAFE Model produces industry-level achieved fuel economy values by running compliance simulations, as plotted in Figure 8-2 (all fleets) and Figure 8-3 (by regulatory class). These figures report achieved fuel economy relative to the estimated fuel economy targets across alternatives; the figures also include results of the achieved fuel economy values that include AC/OC FCIVs and results achieved based on the two-cycle test only.[114] For this analysis, to ensure that simulation of each action alternative begins from the same baseline for MYs 2024-2026, the CAFE Model copies the compliance result for the No-Action Alternative for model years prior to the first standard setting year. The result of this approach is displayed in Figure 8-2 and Figure 8-3. In these model years in the No-Action Alternative, manufacturers' achieved fuel economy is generally below standards, even with AC/OC FCIVs included. In the action alternatives, manufacturers achieve compliance starting in MY 2027.

Examining achieved and target fuel economy levels by regulatory class, Figure 8-3 shows that the domestic and imported passenger automobile fleets consistently fall short of targets in the No-Action Alternative, while the non-passenger automobile fleet meets (or nearly meets) the standards. In the action alternatives, domestic and imported passenger automobile fleets over-comply to a significant degree in 2027 and to a lesser degree in the following model years. The non-passenger automobile fleet follows the same pattern,

[114] This reason for this is to show the change from removal of AC/OC in MY 2028 on manufacturer compliance.

though with less over-compliance in all model years. The pattern of changes between MY 2027 and MYs 2028-2031 is a result of the vehicle classification changes and the removal of FCIVs both going into effect for MY 2028.

Apart from the effect of lower CAFE standards in the regulatory alternatives, some of the over-compliance observed in the fleets under those alternatives is the result of projected “inheritance” of technologies (e.g., changes to engines shared across multiple vehicle models/configurations) applied in earlier model years in response to the existing standards. Other factors, such as fuel prices, also play a role. NHTSA assumes that, besides fuel economy improvements made in response to CAFE standards, manufacturers also apply fuel economy improvements that, given projected fuel prices, would pay for themselves within the first 36 months of vehicle operation. While these factors may increase the industry-wide fleet level over-compliance, the impacts vary considerably among specific manufacturers.

Figure 8-2: Fleet Modeled Fuel Economy

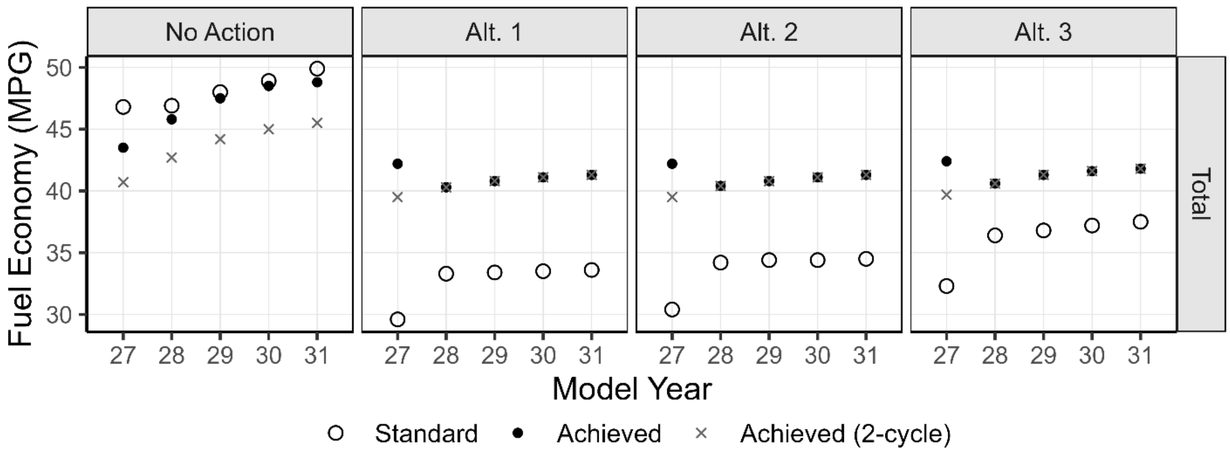


Figure 8-3: Fleet Modeled Fuel Economy by Regulatory Class

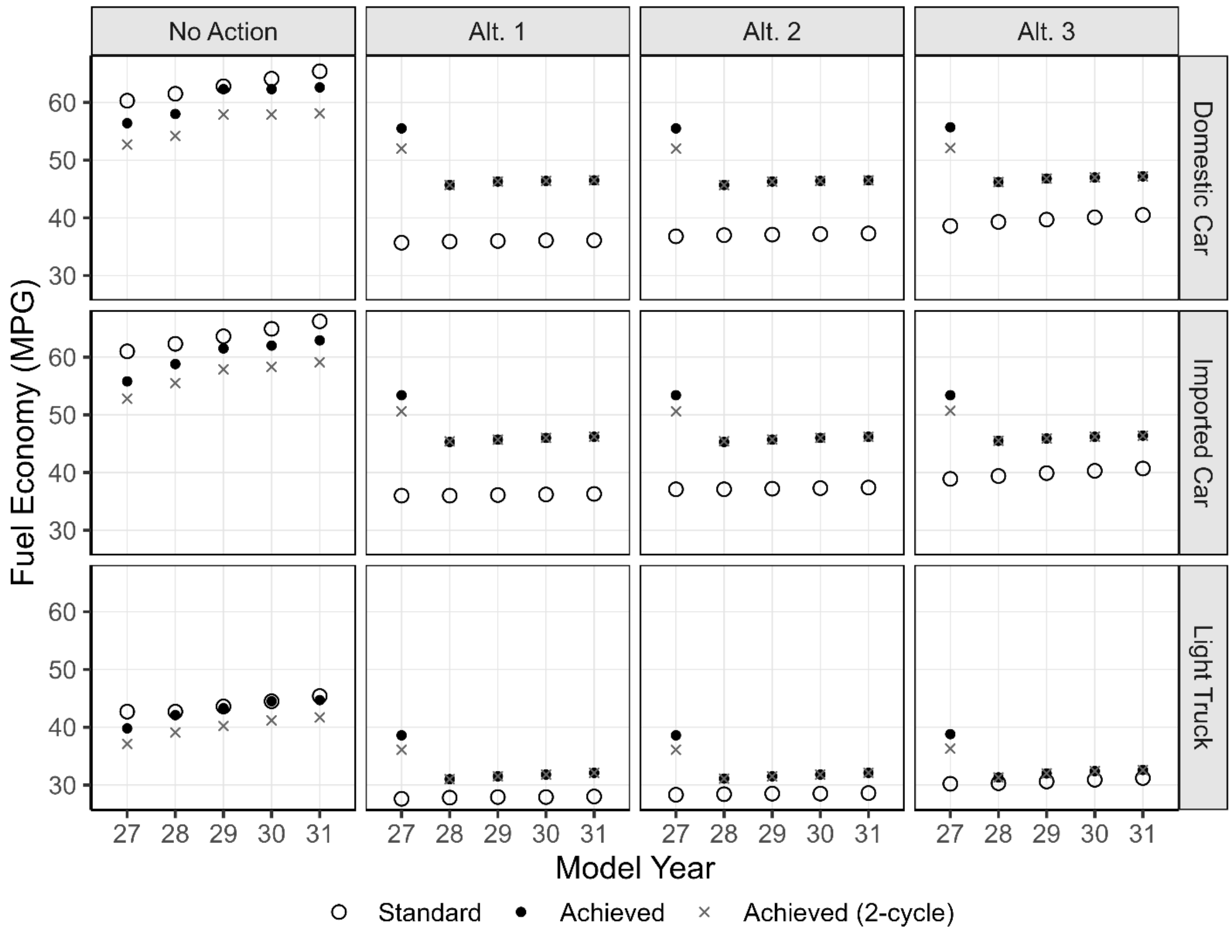
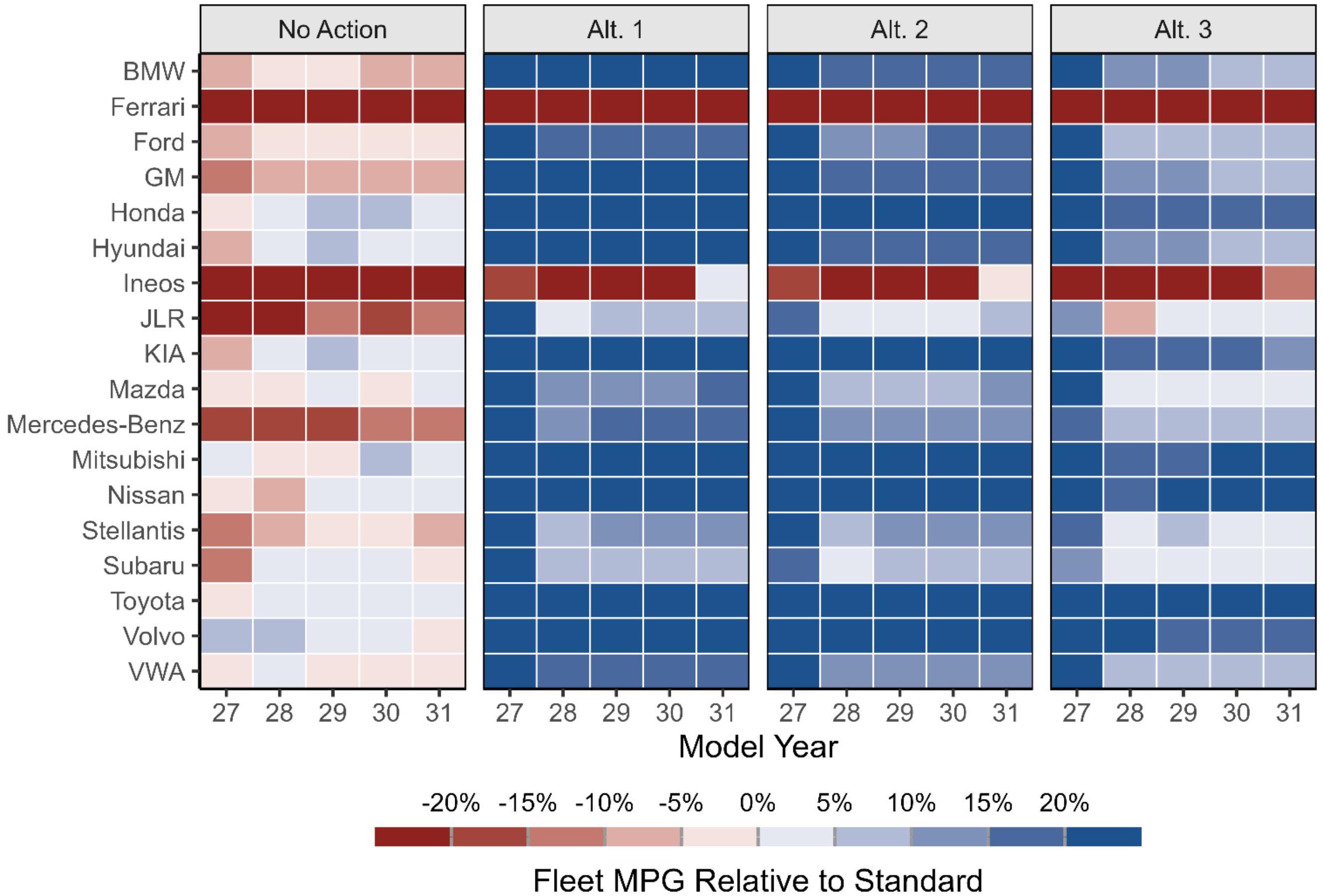


Figure 8-4 presents manufacturer-level differences between achieved and required fuel economy levels on a fleetwide basis. Lighter colored shading represents manufacturer-years with small estimated differences between standards and achieved efficiency levels. Darker shaded regions indicate larger differences between standards and achieved efficiency levels. Regions shaded blue indicate manufacturer fleets that are more efficient than required and those shaded red fall short of their compliance thresholds.[115]

Figure 8-4 illustrates how all the manufacturers in the fleet would be projected to comply with CAFE requirements. Almost all manufacturers (except for Ferrari and INEOS) meet the standards in every action alternative and year. Manufacturers such as Honda, Mitsubishi, Nissan, Toyota, and Volvo exceed targets by 15 percent or more in every alternative at the fleet level, while others, such as Subaru, Stellantis, and Mazda exceed standards by smaller margins.

[115] To preserve the color gradient in Figure 8-4 and Figure 8-5, compliance that exceeds standards by more than 20 percent (or falls short by more than 20 percent) falls into the highest (lowest) color category.

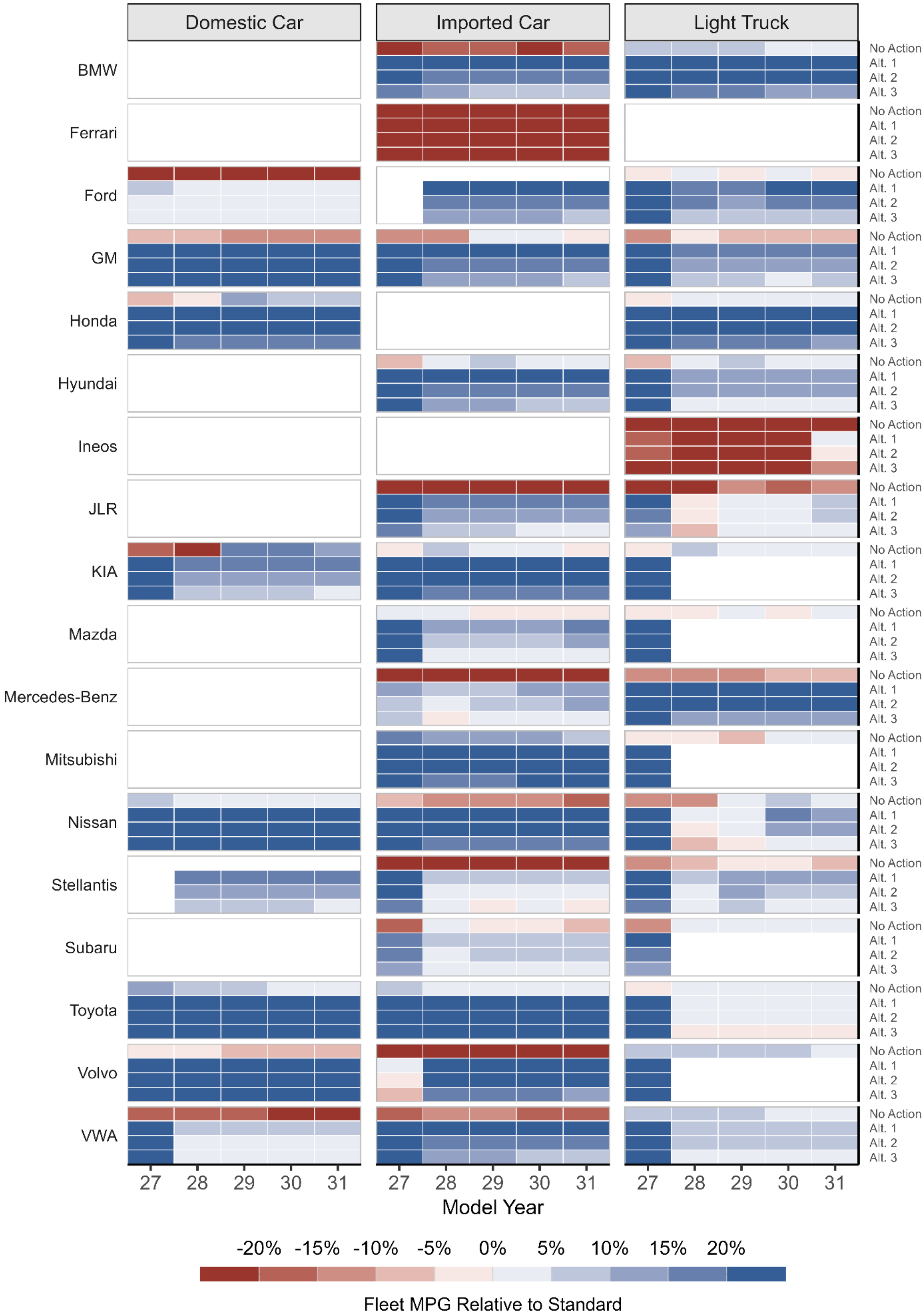
Figure 8-4: Modeled Fleetwide Achieved CAFE by Manufacturer



Within manufacturer fleets, there is heterogeneity in the modeled response by regulatory class. Figure 8-5 separates achieved fuel economy levels by manufacturer and fleet and shows relative compliance in each alternative.[116] Each individual panel represents a manufacturer's achieved fuel economy levels relative to the standard within a regulatory class. White cells indicate a manufacturer has no presence in that regulatory class. Examining results across columns in the figure illustrates that some manufacturers achieve different levels of compliance across regulatory classes. Mercedes-Benz, for instance, over-complies in their light truck fleet (in all scenarios except the No-Action Alternative), but barely complies in their imported car fleet. Nissan is projected to operate inversely, over-complying in its imported car fleet but slightly over- or under-complying in its light truck fleet, dependent upon year and action alternative. Toyota, General Motors (GM), KIA, and Volvo show more consistent performance across regulatory classes and stringency alternatives.

[116] Note that the No-Action Alternative represents standards present in the 2024 final rule. In the No-Action Alternative, this figure measures compliance relative to that standard.

Figure 8-5: Modeled Achieved CAFE Levels by Manufacturer and Regulatory Class



8.2.2. Technology Application

To meet the required CAFE standards under each regulatory alternative, the CAFE Model simulates compliance by applying various technologies (see Draft TSD Chapter 2.1.1) to vehicle models in a manufacturer's regulated fleet. As shown in Figure 8-6, the quantity of technology application varies little across alternatives even given their differences in stringency. However, more fuel economy technology is applied in MYs 2027-2029 of the analysis, with technology application slowing in MYs 2030-2031.

Figure 8-6: Timing of Technology Application in Response to Regulatory Alternatives

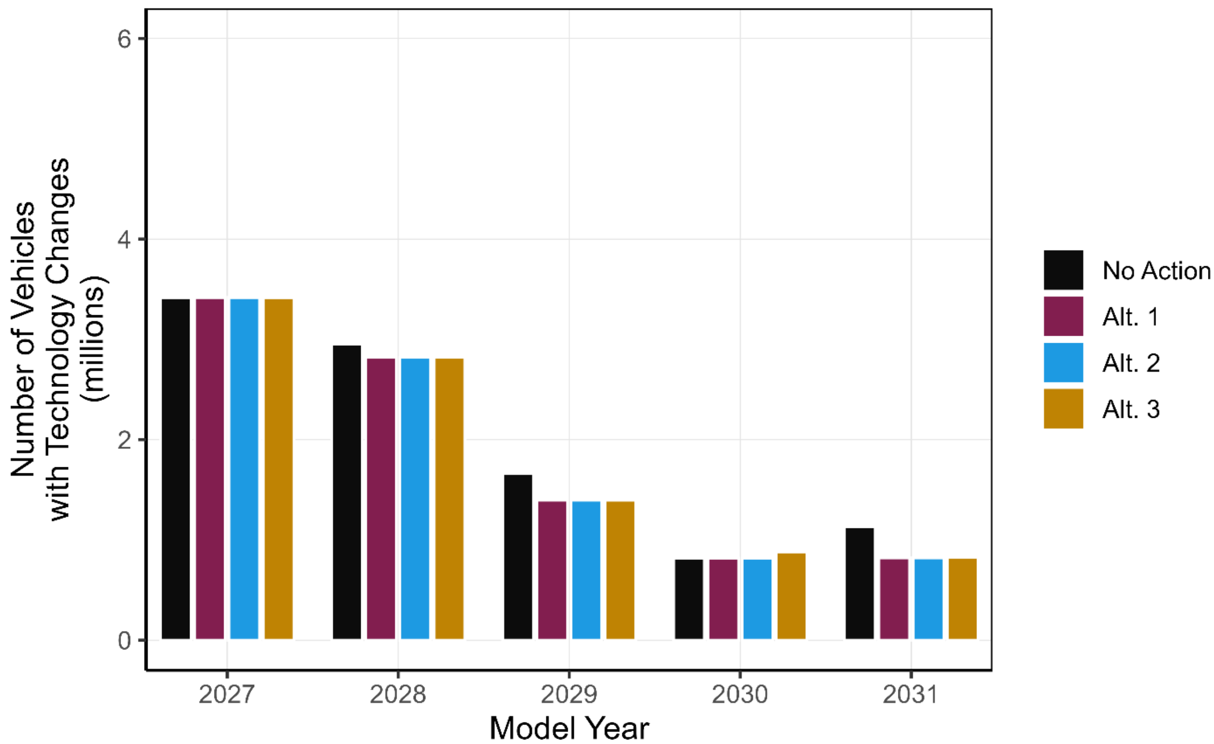


Figure 8-7 throughFigure 8-10 present the resulting industry-wide technology penetration rates across alternatives. Each horizontal line segment in the figure represents the change in technology penetration between MY 2027 (represented by a short vertical line segment) and MY 2031 (represented by a circle). Arrows indicate the direction of the change, and line colors represent the different regulatory alternatives. Between MYs 2027-2031, the CAFE Model estimates reveal several trends, displayed on Figure 8-7,**Error! Reference source not found.** which include:

- Penetration of strong hybrid electric vehicle (SHEV) technology increases from MYs 2027-2031. Differences between alternatives are small, but in all cases the penetration rates for the alternatives are less than the No-Action Alternative.
- Penetration of stop/start 12V (SS12V) technology decreases significantly from MYs 2027-2031, as does staying with conventional engine technology.
- Penetration of belt-integrated starter generator (BISG) also decreases to near zero. The change is small because the use of this technology prior to this analysis was also small.

Figure 8-7: Prevalence of Advanced Powertrain Technology in the Fleet Under Different Regulatory Alternatives[117]

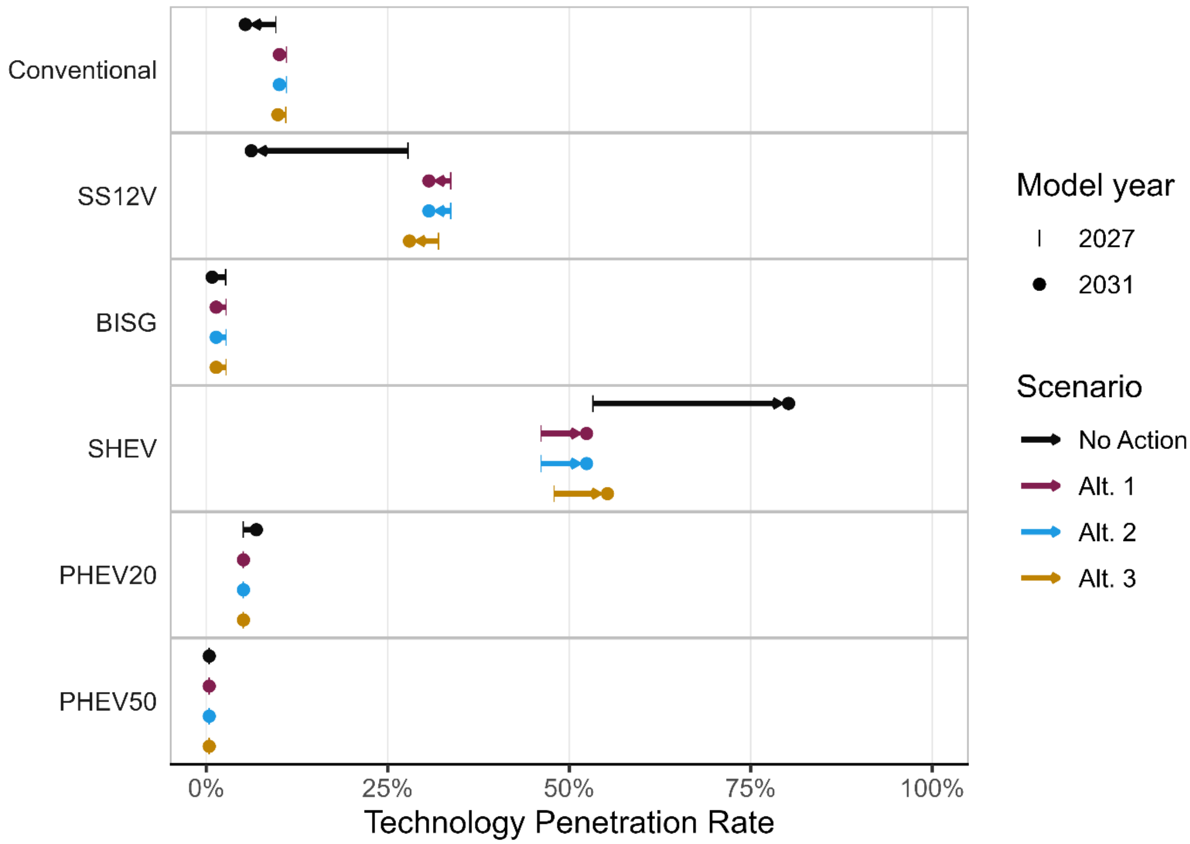


Table 8-1 below breaks out the data presented in Figure 8-7 per year but presents the penetration data for Alternatives 1 through 3 relative to the No-Action Alternative. For the No-Action Alternative rows in Table 8-1, penetration levels are shown. Note that the SHEV penetration is reduced by nearly 30 percent in the final standard setting year (2031) for the three alternatives. In contrast, use of advanced gasoline engine technologies increases.

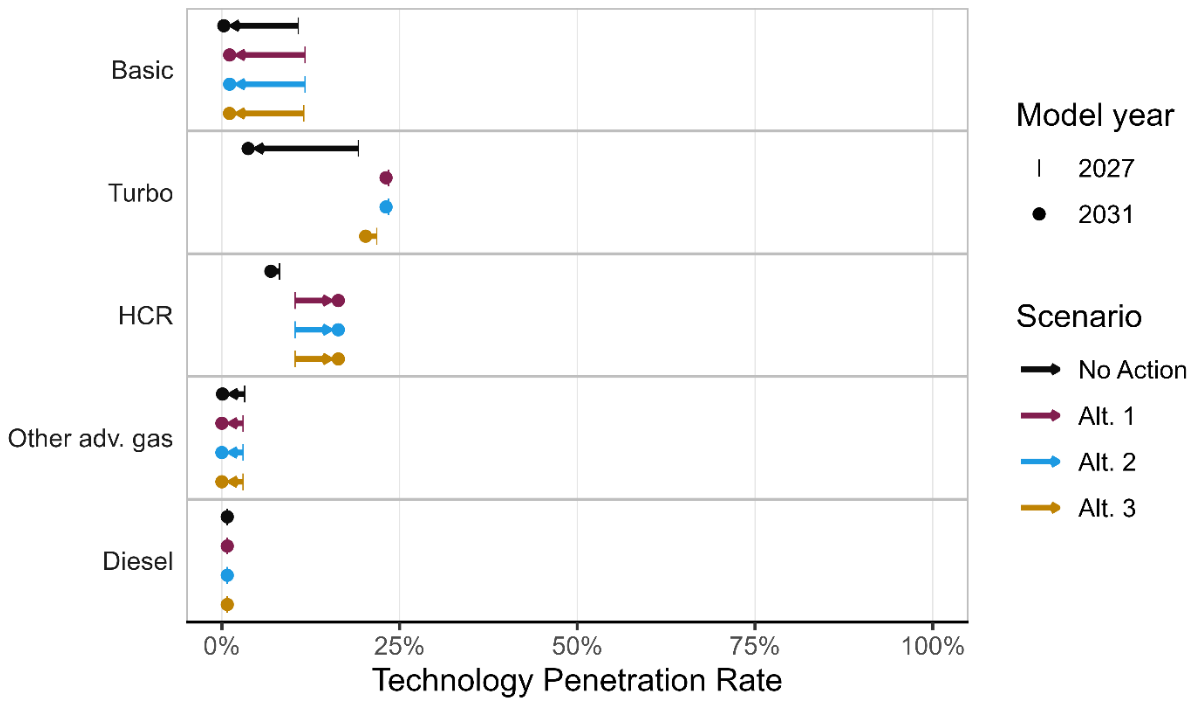
Table 8-1: Advanced Powertrain Technology Penetration Rates by Model Year (No-Action Case Levels and Alternatives Relative to No-Action)[118]

	2027	2028	2029	2030	2031
Advanced gasoline engines					
No-Action	17.7	12.9	6.7	2.7	1.9
Alt. 1	+2.0	+5.1	+8.9	+11.5	+12.4
Alt. 2	+2.0	+5.1	+8.9	+11.5	+12.4
Alt. 3	+1.9	+5.0	+7.9	+10.4	+11.1

[117] The advanced powertrain technologies shown are defined in Draft TSD Chapter 2.1.1.
[118] Advanced powertrain technology includes turbocharging, cylinder deactivation, variable-compression-ratio engines, Atkinson-cycle engines, high-compression-ratio engines, and variable-inlet-geometry turbochargers.

SHEV					
No-Action	53.3	62.4	71.7	76.7	80.2
Alt. 1	-7.1	-13.9	-21.3	-25.4	-27.8
Alt. 2	-7.1	-13.9	-21.3	-25.4	-27.8
Alt. 3	-5.4	-12.1	-18.5	-22.6	-24.9
PHEV					
No-Action	5.5	7.3	7.3	7.3	7.3
Alt. 1	+0.0	-1.8	-1.8	-1.8	-1.8
Alt. 2	+0.0	-1.8	-1.8	-1.8	-1.8
Alt. 3	+0.0	-1.8	-1.8	-1.8	-1.8

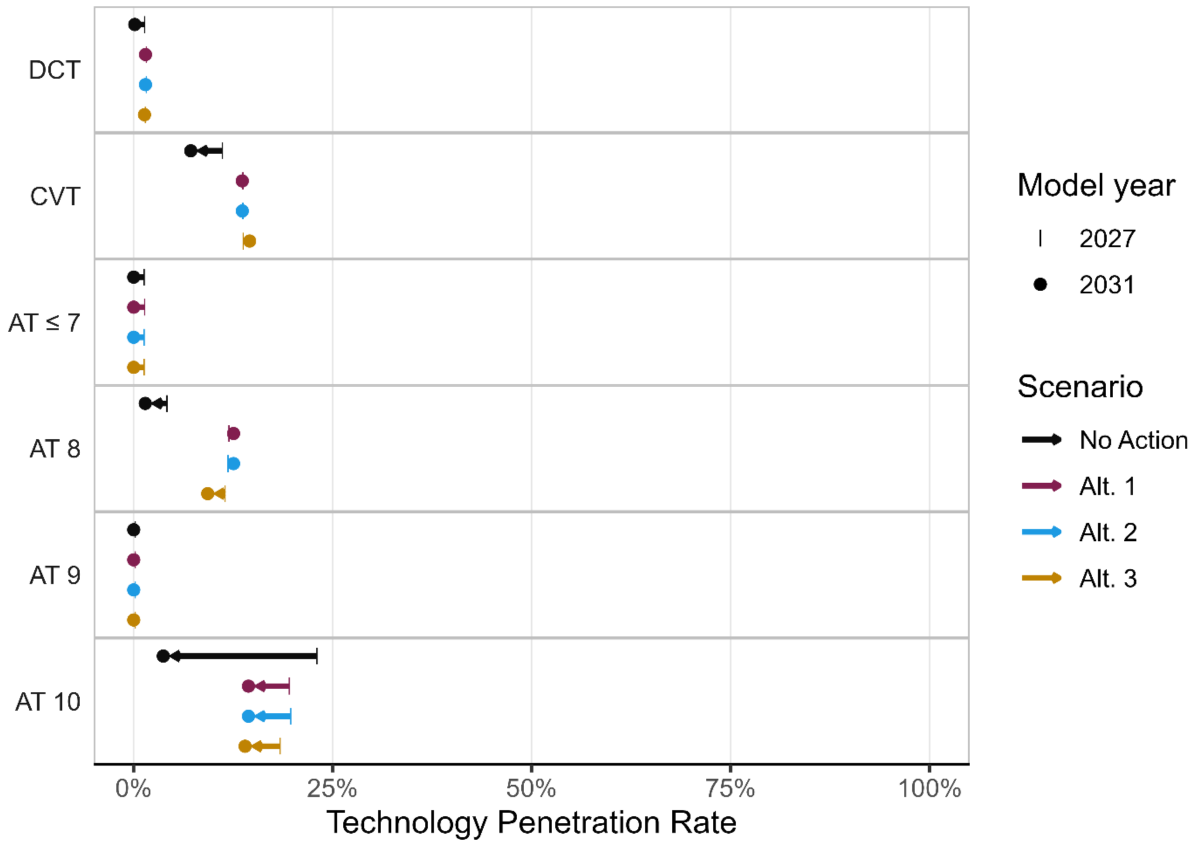
Figure 8-8: Prevalence of Engine Technology in the Fleet Under Different Regulatory Alternatives[119]



- The modeled fleet sees an increase in penetration of high compression ratio (HCR) engine technology by a few percentage points for all alternatives except the No-Action Alternative.
- Basic engine technology applications decrease, as does the penetration of turbo technology and other advanced combustion engine technology.
- Penetration of diesel technology stays the same, at very low levels—about 1 percent.

[119] The engine technologies shown are defined in Draft TSD Chapter 2.1.1.

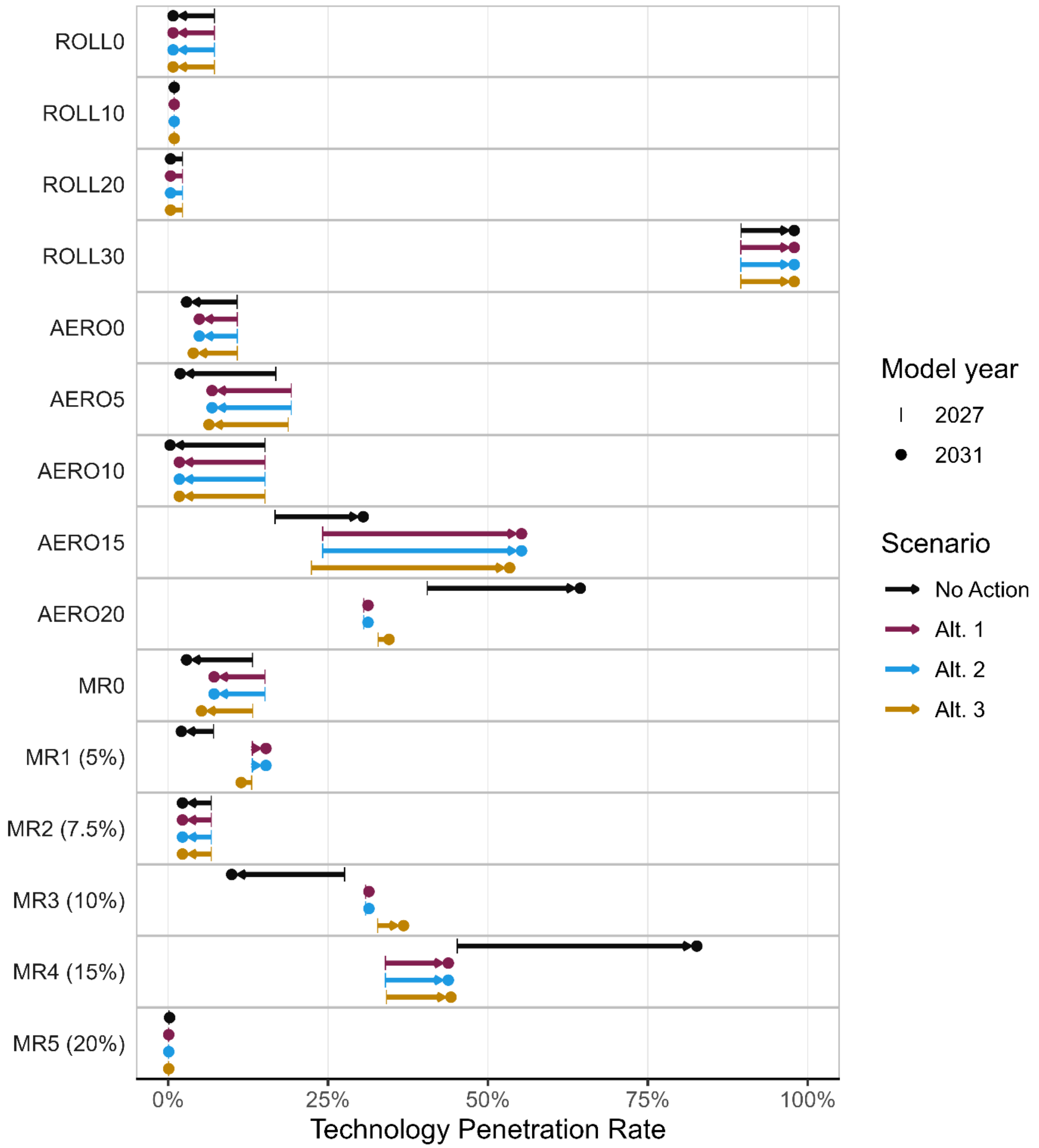
Figure 8-9: Prevalence of Transmission Technology in the Fleet Under Different Regulatory Alternatives[120]



- From MYs 2027-2031 the penetration of AT7 decreases to near zero and the penetration of AT9 stays constant across all alternatives. In addition, for AT8, the penetration increases slightly for Alternatives 1 and 2, and AT10 penetration decreases the most for all alternatives, to a greater extent for the No-Action Alternative.
- Penetration of dual-clutch transmissions stays constant, except for the No-Action Alternative, where the penetration decreases to near-zero.
- Note that the transmission technology in Figure 8-9 represents standalone transmissions. This figure does not account for the penetration rate of these transmission types as a component of strong hybrid powertrains.

[120] The transmission technologies shown are discussed in Draft TSD Chapter 2.1.1.

Figure 8-10: Prevalence of Tire Rolling Resistance, Aerodynamics, and Mass-Reduction Technologies in the Fleet Under Different Regulatory Alternatives[121]



- Rolling Resistance (ROLL):
    - Results are very similar across scenarios.
    - With few exceptions, ROLL30 is applied to all models by MY 2031.
- Aerodynamics (AERO):
    - The amount of AERO0 through AERO10 applied is reduced in favor of applying AERO15.
    - For all stringency alternatives, aerodynamic improvement technologies are applied at roughly the same amounts, except for the No-Action Alternative under AERO20 which shows an increase in penetration of over 15 percent.

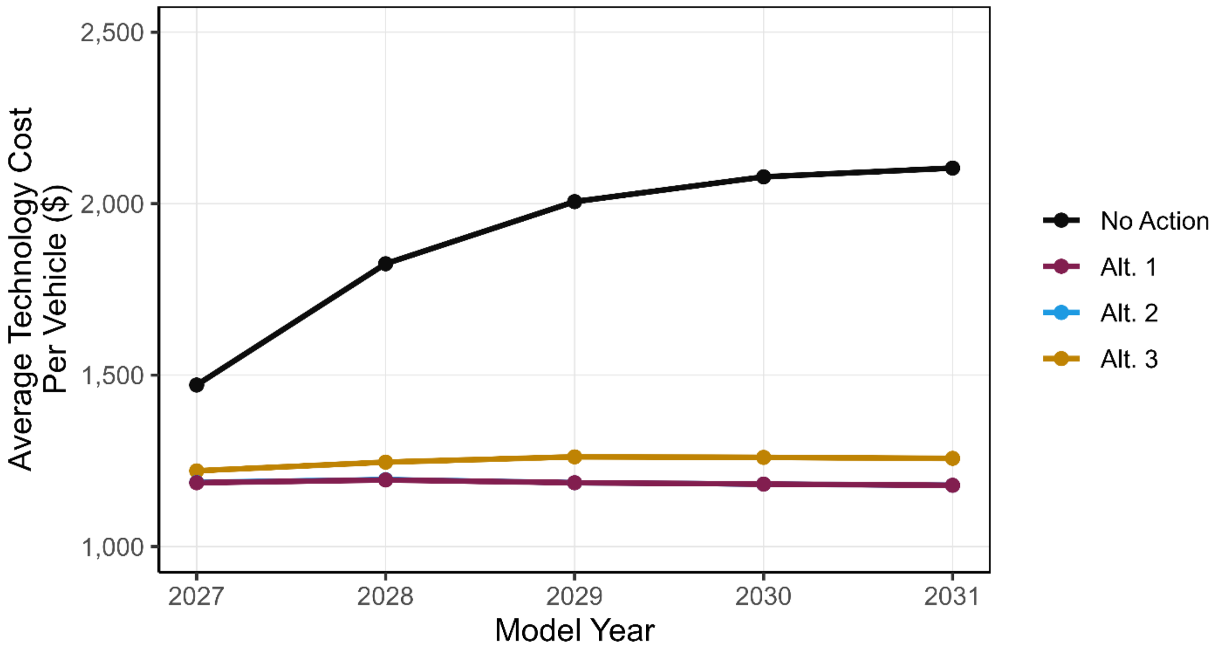
[121] The road load reduction technologies shown are defined in Draft TSD Chapter 2.1.1.

- Mass Reduction (MR):
    - The amount of MR0 through MR3 applied is reduced in favor of MR4.
    - The amount of MR4 is applied roughly the same across the three stringency alternatives. Under the No-Action Alternative, MR4 increases more than for the other three alternatives.
    - The penetration rates of MR5 remains roughly the same across all years and stringency alternatives. Penetration rates for MR5 are less than 2 percent.

8.2.3. Compliance Costs

The CAFE Model computes aggregate and per-vehicle technology costs, which represent the regulatory cost, as well, for this analysis. Figure 8-11 reports industry-wide, model-year trends in per-vehicle technology costs. Note that Alternatives 1 and 2 are very similar in their outcomes, such that they lie on top of one other in the graph, obscuring the technology cost from Alternative 2. Alternative 3 is only slightly more costly than Alternatives 1 and 2.

Figure 8-11: Average Per-Vehicle Technology Cost



Per-vehicle technology costs vary widely by manufacturer and across alternatives, in part due to estimated technology application choices. In the real world, however, manufacturers are always free to comply using any technologies they choose, including ones that are more cost-effective than those modeled here.[122]

Figure 8-12 presents per-vehicle technology costs for a MY 2031 vehicle in the reference baseline. Gray bars in the figure show costs in the No-Action Alternative. Total No-Action Alternative costs are listed in the data labels in the "No-Action" panel. The portions of the bar in color represent the changes in manufacturer technology costs for each action alternative compared to the No-Action Alternative. For example, average per-vehicle technology costs for Volkswagen Group of America (VWA) in the No-Action Alternative are $2,190. Under Alternative Action 1 and 2, these costs decrease by $770 per vehicle to $1,420. Under Alternative 3, these costs decrease by $650 per vehicle to $1,540. Manufacturers including GM, Hyundai, Mazda, Stellantis, Subaru, and KIA see decreases in per-vehicle technology costs under all alternatives. For another example, Mazda's per vehicle cost decreases by $1,480 in all action alternatives. Mazda's fleetwide application of high-level AERO and mass reduction technology (AERO15 and MR3) increase across these

[122] NHTSA does not allow the CAFE Model to consider the fuel economy of powertrains fueled by alternative fuels as a compliance strategy to meet the standards, consistent with statutory restrictions.

alternatives, due to Mazda's high level of platform sharing.[123] In addition, Mazda produces about 50 percent fewer SHEVs in the action alternatives compared to the baseline, which also results in decreased technology costs.

Relative to the No-Action Alternative scenario, Alternatives 1 and 2 would result in an average industry-wide decrease in per-vehicle technology costs of $930—a decrease of 44 percent. Alternative 3 represents an average industry-wide decrease in per-vehicle technology costs of $850—a decrease of 40 percent.

Figure 8-12: Per-Vehicle Technology Cost, MY 2031 Vehicle

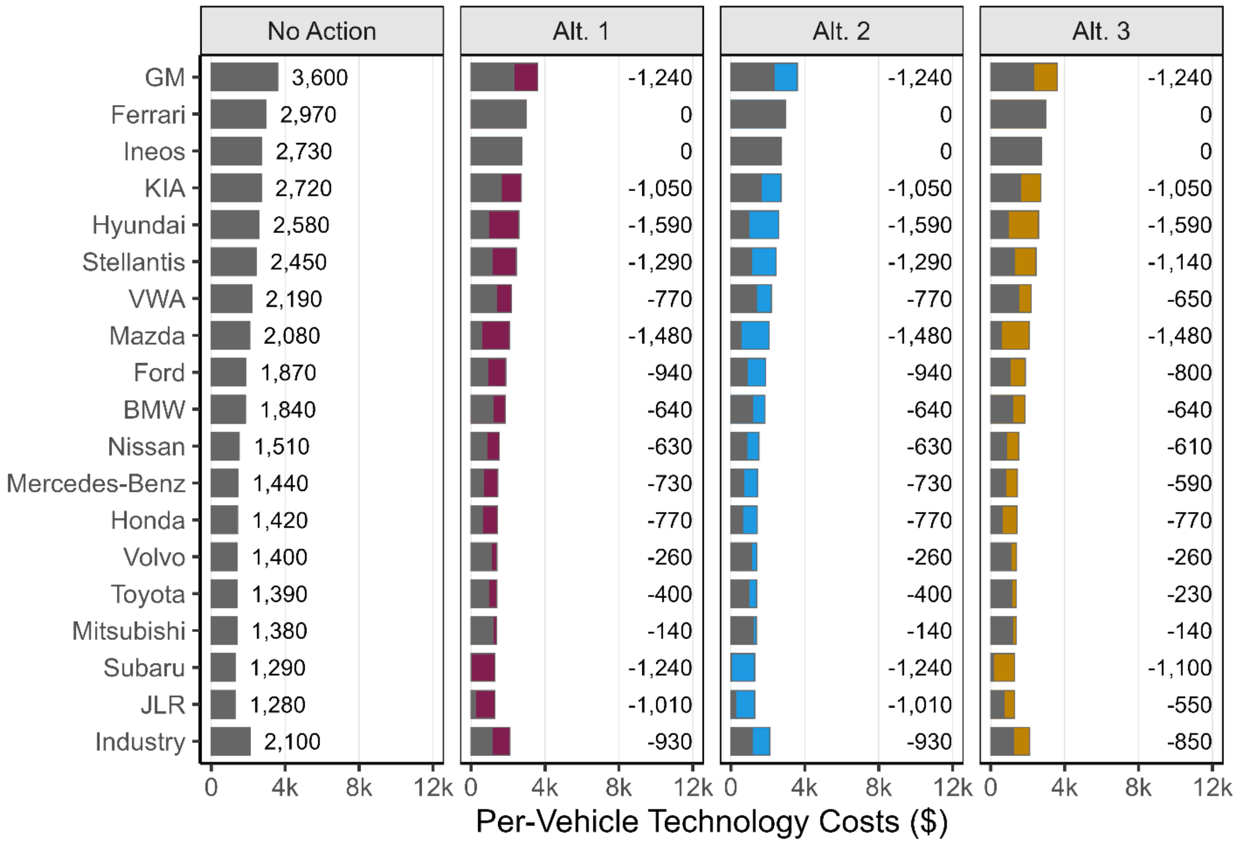
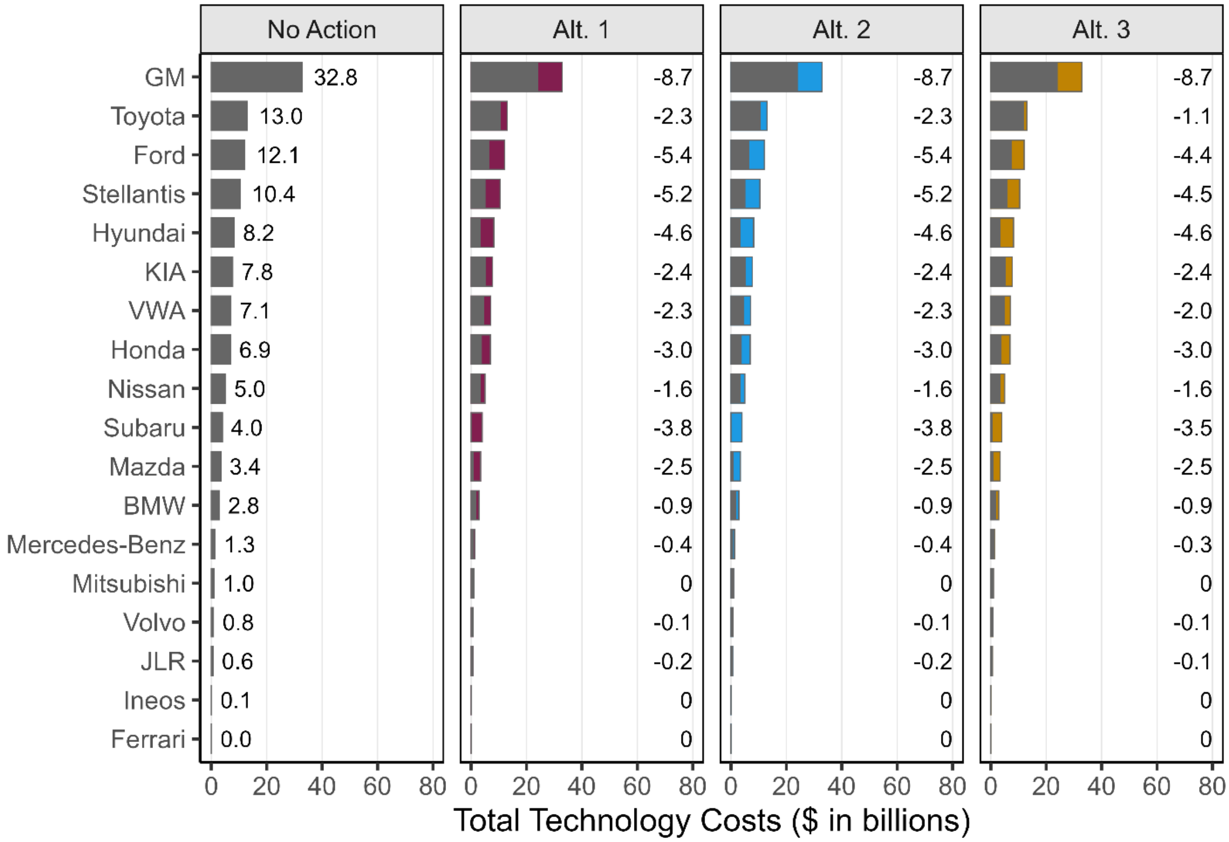


Figure 8-13 reports total technology costs for MYs 2027-2031. Gray bars in the figure are costs in the No-Action Alternative. Total No-Action Alternative costs are listed in the data labels in the "No-Action" panel. The portions of the bar in color represent the changes in manufacturer technology costs for each action alternative. In most cases, differences in manufacturer rankings between Figure 8-12 and Figure 8-13 are the result of production-scale variation (e.g., Ford's large production volumes means it has the third largest total technology cost even though Ford's average per-vehicle costs place it in the middle of the manufacturer ranking in Figure 8-12).

[123] See Draft TSD Chapter 2 for a discussion on the platform sharing assumptions used in this analysis.

Figure 8-13: Technology Costs by Manufacturer, MYs 2027-2031



8.2.4. Sales and Employment Impacts

As manufacturers modify their vehicles and utilize fuel economy-improving technologies in response to CAFE standards, the costs of vehicles offered in the marketplace will change. The analysis assumes that these cost changes are passed on to consumers, with lower retail prices increasing vehicle sales. Because the technology cost savings in each of the action alternatives exceeds the value of expected incremental fuel expenditure in the first 36 months, sales increase in each alternative relative to the No-Action Alternative.[124] Figure 8-14 illustrates the magnitude of this effect in the context of total sales of gas-powered vehicles, which are forecast to decline somewhat over the long term. More details about NHTSA's projection of total sales can be found in Draft TSD Chapter 4.2.[125]

[124] Sales differences among alternatives are dictated by the assumed price elasticity of demand and the change in vehicle price net of future fuel savings. For this analysis, the assumed price elasticity is -0.4 and the model assumes new vehicle buyers value the first 2.5 years of future fuel savings. Draft TSD Chapter 4.2 provides a detailed discussion of these assumptions.
[125] NHTSA's projection of total sales excludes BEVs and FCEVs.

Figure 8-14: Industry-Wide Sales

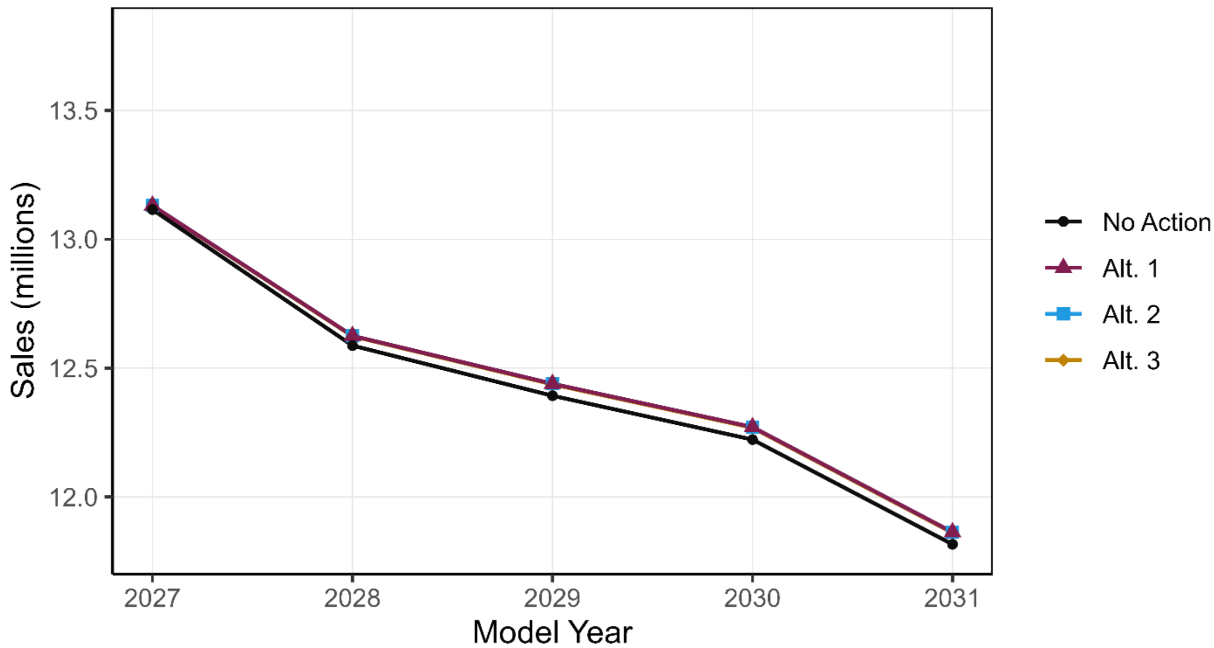


Figure 8-15 shows the simulated sales differences for the current analysis at the industry level across alternatives compared to the No-Action Alternative. Beginning in MY 2027, sales begin to increase in all scenarios compared to the No-Action Alternative. As stringency levels increase across scenarios (moving from Alternative 1 to Alternative 3) and technology costs increase, the overall magnitude of the sales increase lessens. As can be seen in Figure 8-15, there is relatively little variation across the three action alternatives, with all three trend lines lying roughly on top of each other. In Figure 8-16, Alternative 1 and 2 have no visual difference. Sales are highest in Alternative 1 and 2 (within 0.02 percent of each other), and within 0.1 percent of Alternative 3. Through MY 2050, no alternatives differ from the No-Action Alternative by more than 0.5 percent.

Figure 8-15: Percentage Change in Sales, by Alternative

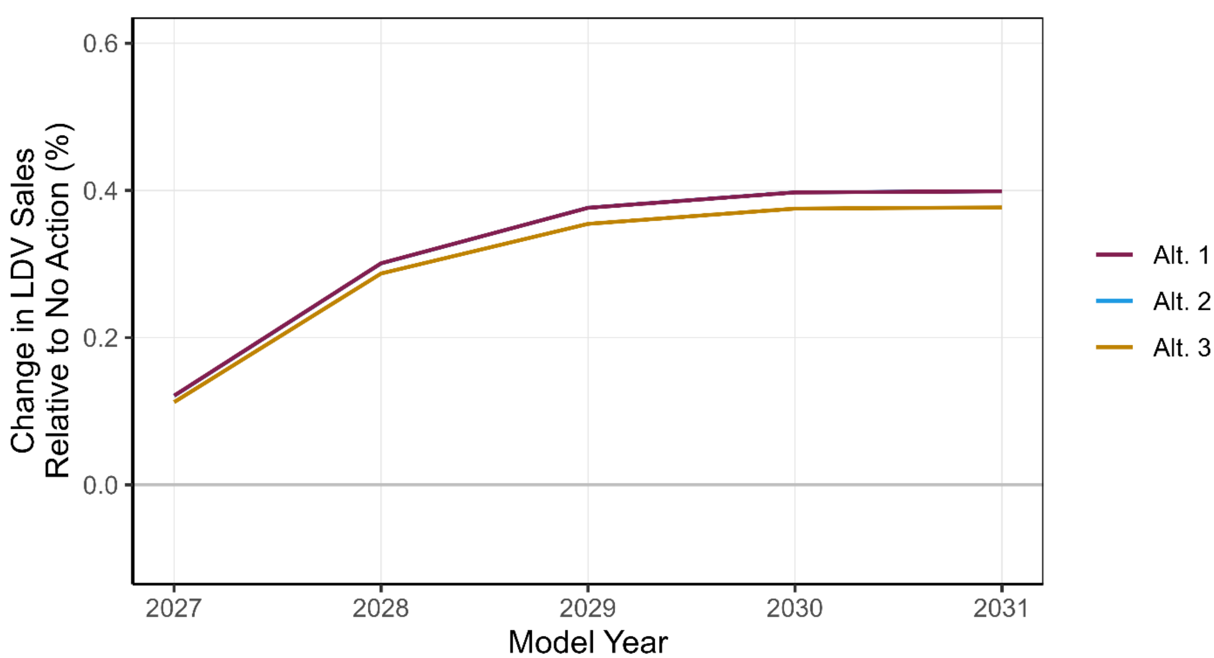
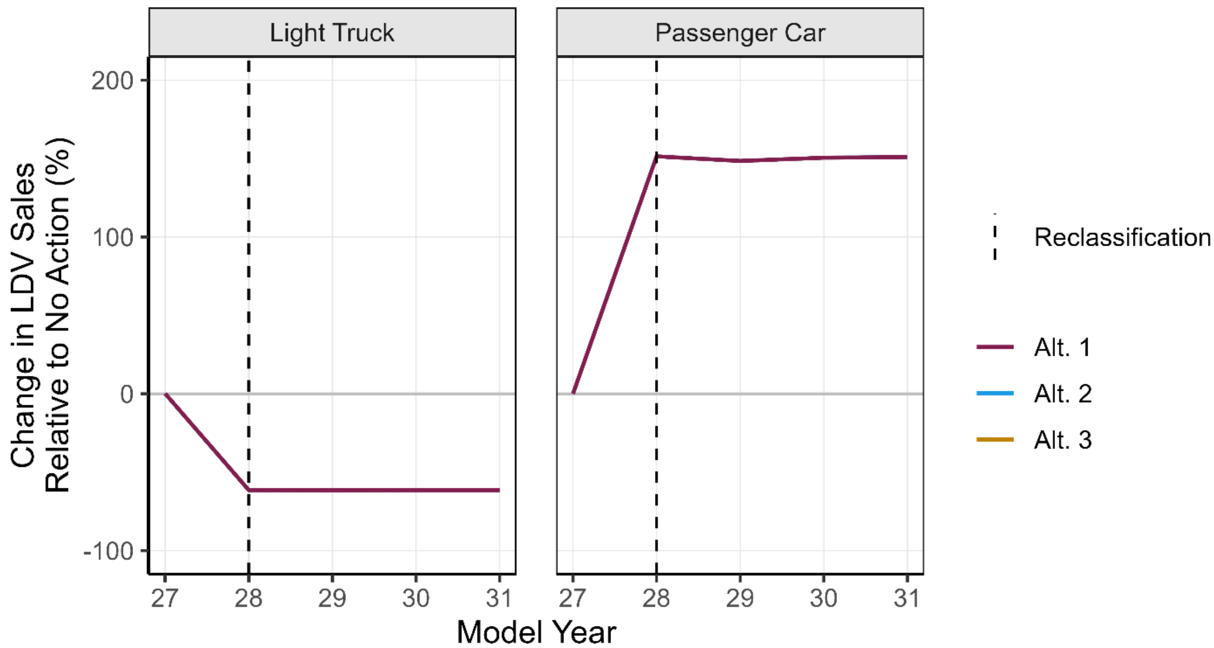


Figure 8-16 presents the projected differences in the sales response across regulatory classes. In the alternative scenarios presented here, the trend in sales for the light truck fleet declines sharply in MY 2028 as reclassification occurs, then holds constant through MY 2031. For the passenger car fleet, there is a jump of more than 100-percent change in sales relative to the No-Action Alternative in MY 2028 due to reclassification and then a slight gradual change in sales. All the action alternatives are within 1 percent of each other. Due to this relatively small variation across action alternatives and the scale of Figure 8-17, this results in all three trend lines lying on top of each other, obscuring Alternatives 2 and 3 from the graph.

Draft TSD Chapter 4.2 provides additional discussion of the sales model methodology and assumptions. Chapter 9 also presents sensitivity analysis results for the assumed fleet share elasticity. The relative changes in sales for these two regulatory classes feeds into the analysis of on-road fleet and aggregate vehicle use, which is explored more in detail in Chapter 8.5.1.

Figure 8-16: Percentage Change in Sales, by Alternative and Regulatory Class



When more vehicles are sold, manufacturers require more labor hours to produce vehicles to satisfy demand. However, a decreasing need for the development and application of costly fuel economy-improving technologies decreases demand for labor. Overall estimated CAFE program impacts on employment utilization depend on the relative magnitude of these two factors. Table 8-2 reports total employment utilization in full-time equivalent job units (i.e., the number of individuals working a full-time position that are required to meet new vehicle demand). Chapter 6.2.5 of the Draft TSD provides further detail on this measure and how it is calculated.

In the No-Action Alternative, net employment utilization mostly increases until it peaks in MY 2027 and then declines through MY 2032, increasing briefly again in MY 2033, then steadily declining through MY 2050. Employment utilization decreases in each action alternative relative to the No-Action Alternative. Alternatives 1 and 2 show almost identical decreases in labor utilization, while for each model year, Alternative 3 sees the smallest decrease in labor over the No-Action Alternative.

Since the decrease in labor is largest in the less stringent alternatives, this indicates that the technology effects outweigh the sales effects in the action alternatives. The impact of decreased demand for fuel economy-improving technologies is larger in magnitude than the increase in demand that results from increased vehicle sales. The trend of incremental labor utilization in the action alternatives generally follows that seen in the No-Action Alternative: the incremental difference grows until MY 2033 and then steadily declines through MY 2050.

Table 8-2: Industry-Wide Labor Utilization Effects (in Full-Time Equivalent Jobs)

Model Year	No-Action Alternative	Difference From No-Action		
		Alt. 1	Alt. 2	Alt. 3
2024	887,000	0	0	0
2025	865,000	0	0	0
2026	873,000	0	0	0
2027	874,000	-1,680	-1,690	-1,300
2028	846,000	-4,240	-4,250	-3,750
2029	834,000	-6,350	-6,350	-5,540
2030	824,000	-6,970	-6,970	-6,130
2031	797,000	-7,190	-7,190	-6,400
2032	774,000	-7,120	-7,120	-6,340
2033	793,000	-7,650	-7,650	-6,840
2034	781,000	-7,530	-7,530	-6,740
2035	770,000	-7,390	-7,400	-6,620
2036	765,000	-7,370	-7,370	-6,590
2037	759,000	-7,230	-7,230	-6,490
2038	755,000	-7,110	-7,110	-6,430
2039	750,000	-6,780	-6,780	-6,120
2040	746,000	-6,620	-6,620	-6,010
2041	740,000	-6,530	-6,530	-5,920
2042	735,000	-6,430	-6,430	-5,830
2043	727,000	-6,320	-6,320	-5,740
2044	723,000	-6,260	-6,260	-5,690
2045	718,000	-6,200	-6,200	-5,630
2046	713,000	-6,100	-6,100	-5,540
2047	708,000	-6,010	-6,010	-5,400
2048	700,000	-5,820	-5,820	-5,230
2049	693,000	-5,740	-5,740	-5,150
2050	684,000	-5,670	-5,670	-5,090

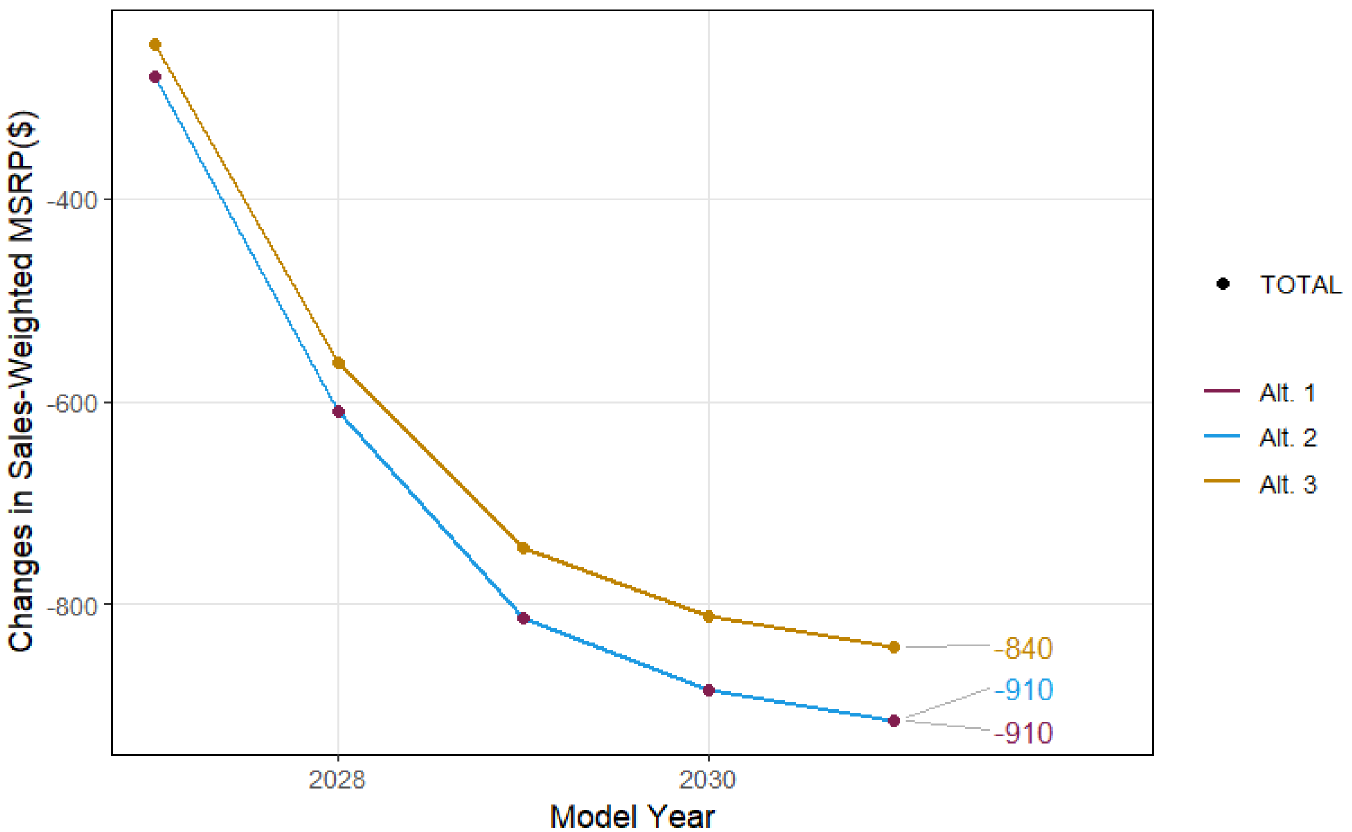
8.3. Effects on New Car and Truck Buyers

8.3.1. Vehicle Purchase Prices

The CAFE Model uses vehicle-level manufacturer suggested retail price (MSRP) values provided in the input fleet as the starting point for modeling light duty vehicle purchase prices. These initial MSRPs are revised over successive model years to produce final MSRP values that incorporate the regulatory cost of compliance. The prices do not include the effects of any tax credits passed through to consumers.[126] Figure 8-17 displays trends in these MSRPs for MYs 2024-2031, relative to the No-Action Alternative for the total fleet. The prices of vehicles in the fleet average 0.2 percent lower across alternatives relative to the baseline. Because these prices are determined by technology application, the overall price trends are similar to those found in Chapter **Error! Reference source not found.**.1.3, which presents average technology cost per vehicle. Alternatives 1 and 2 result in very similar MSRP changes for the fleet and are therefore indistinguishable in the Figure.

One effect of the proposed reclassification of the fleet in MY 2028 is that examining incremental effects of MSRP changes from the No-Action Alternative to the action alternatives is no longer particularly informative, because the reclassified passenger car fleet in MY 2028 includes comparatively more expensive vehicles (largely SUVs) shifted from the light truck regulatory class, and the light truck class now comprises largely more expensive vehicles (the less expensive vehicles being reclassified to the passenger car fleet). This leads to an increase in the average price of each regulatory class and a decrease in the average price for the fleet as a whole, a phenomenon known as “Simpson’s paradox.”[127] While shifting SUVs from the light truck to passenger car fleet increases the target function values for some individual vehicles, in general the action alternatives are less stringent, resulting in lower prices compared to the baseline.[128] Accordingly, NHTSA presents only the total fleet MSRP changes below; more granular estimates of how individual vehicle MSRPs change over time in response to standards values can be found in the Vehicle Report Output File.

Figure 8-17: Changes in Sales-Weighted Average MSRP Relative to the No-Action Alternative, Total Fleet



[126] While the MSRP reported here does not include the value of tax credits passed through to consumers, these credits are included in MYs 2024-2025 in the sales model as discussed in Chapter 4 of the Draft TSD.
[127] See Sprenger J., & Weinberger N., Simpson’s Paradox, *The Stanford Encyclopedia of Philosophy*, Summer 2021 ed., in E. N. Zalta (ed.), available at: https://plato.stanford.edu/archives/sum2021/entries/paradox-simpson/ (accessed: Sept. 10, 2025).
[128] NHTSA explores the effects of reclassification in PRIA Chapter 9 by a case in which reclassification is performed in both the baseline and the action alternatives and a separate case in which reclassification is not performed in any of the alternatives.

8.3.2. Additional Consumer Purchasing Costs and Benefits

In addition to vehicle price effects, the CAFE Model computes various categories of consumer costs and benefits.[129] Table 8-3 summarizes these cost and benefit categories for MY 2031 vehicles. The table includes per-vehicle aggregate values for the No-Action Alternative and differences from the No-Action Alternative for each of the regulatory alternatives.[130] Insurance cost and vehicle taxes and fees are all derived as a portion of modeled MSRP levels and hence vary directly with MSRP across alternatives. Regulatory costs are calculated based off the compliance pathways explained in Chapter 8.2, and therefore changes are associated with changes in alternative stringency. Because NHTSA is proposing to decrease the stringency of the CAFE standards, costs are expected to decrease relative to the baseline. As shown in Table 8-3, regulatory costs are about 44 percent lower than the No-Action Alternative for Alternative 1 and Alternative 2 and about 40 percent lower for Alternative 3 in MY 2031. Note that the regulatory costs shown in Table 8-2 match the industry-average costs presented in Figure 8-13 (though, in the latter, costs are rounded to the nearest $10).

Estimated consumer benefits of CAFE standards include decreased fuel expenditures, time saved due to less frequent fueling, additional value derived from reallocated VMT, and realized benefits from rebound travel.[131] Because NHTSA is proposing to decrease the stringency of standards, many of these benefits are lower in Alternatives 1, 2, and 3 relative to the baseline. As presented in Table 8-3, in terms of magnitude, fuel savings benefits is the largest component of estimated change in consumer benefits. Estimates for the No-Action Alternative indicate average lifetime retail fuel outlay costs of $16,350 per vehicle in 2031. Additional fuel costs in the alternatives relative to the baseline ranged from $1,256 in Alternative 3 to $1,431 in both Alternative 1 and Alternative 2. Consumer net benefits are positive in each alternative. Overall, the incremental consumer net benefits are higher in Alternative 3 for MY 2031, while Alternatives 1 and 2 have the same, slightly lower, value of consumer net benefits.

Table 8-3: Per-Vehicle Consumer Costs and Benefits, MY 2031 (2024$, 3% Discount Rate)

	No-Action	Relative to No-Action		
		Alt 1	Alt 2	Alt 3
Consumer Costs				
Regulatory cost	2,104	-925	-925	-847
Insurance cost	4,360	-87	-87	-80
Ownership taxes/fees	2,575	-52	-52	-48
Lost consumer surplus	0	-1	-1	-1
Implicit opportunity cost	2,625	-699	-699	-615
Total consumer cost	0	-1,763	-1,763	-1,589
Consumer benefits				
Fuel savings	-16,350	-1,431	-1,431	-1,256
Refueling time benefit	-878	-79	-79	-70
Mobility benefit	1,002	-183	-183	-158
Reallocated mileage benefit	0	-34	-34	-32
Total consumer benefit	0	-1,727	-1,727	-1,516
Net consumer benefit	0	36	36	73

[129] This chapter considers only private consumer costs and benefits. Chapter 8.2.3 presents model results for costs and benefits attributable to society as a whole.
[130] Results for additional regulatory fleet aggregations and discount rates are included in Appendices I and II.
[131] IRA tax credits phase out following MY 2025 in the central analysis and are therefore 0 in MY 2031.

Figure 8-18 reports consumer net benefits per vehicle from MYs 2027-2031. Net consumer benefits are positive during the standard setting years in all the alternatives, as decreases in consumer costs outweigh decreases in fuel savings. Chapter 9 of this document explores the sensitivity of these results to alternative modeling assumptions. Note that Alternative 1 and Alternative 2 are indistinguishable from one another in this graph. NHTSA accounts for forgone improvements in attributes other than fuel economy through the implicit opportunity cost; however, the agency does not account for changes in the fleet mix offered by manufacturers in an effort to comply with standards, including eliminating some models entirely. Since the proposed standards would prevent these distortionary effects, it would increase the range of choices available to Americans and would, thus, provide additional benefits to new car and truck buyers.

Figure 8-18: Private Consumer Net Benefits, Light-Duty Vehicles, 3% Social Discount Rate

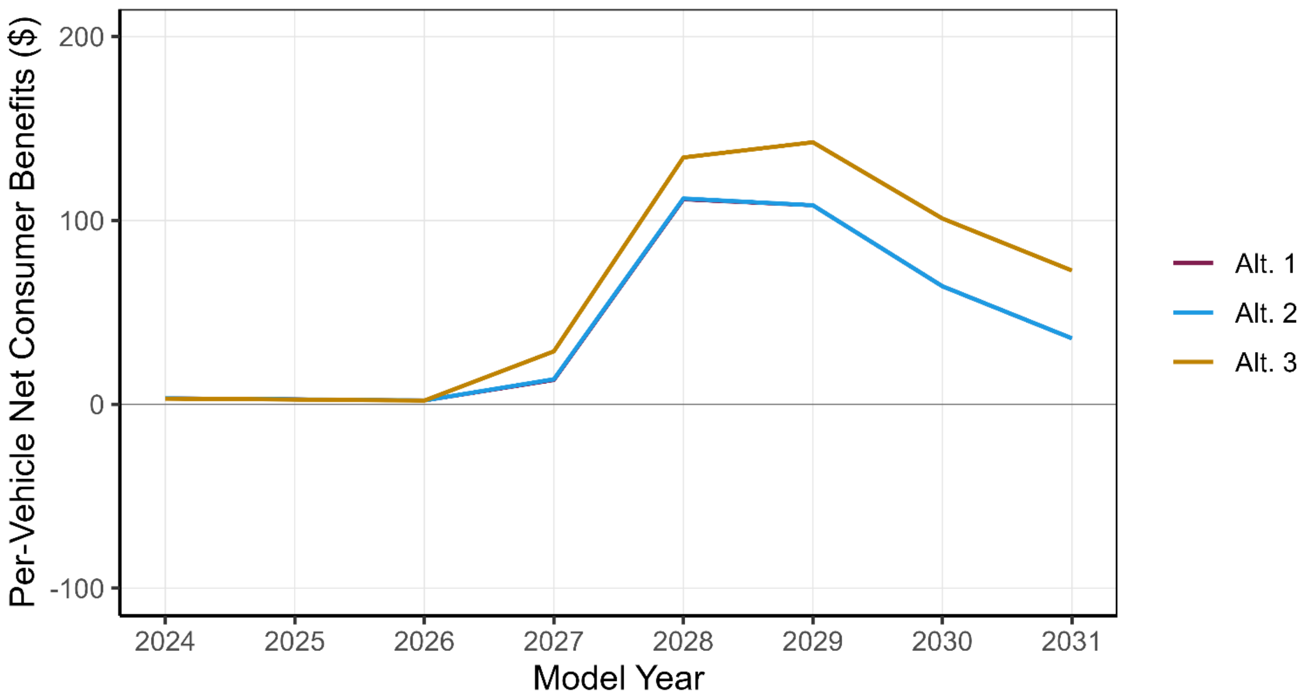


Figure 8-19 plots trends in each of the consumer cost components directly tied to vehicle MSRP. As expected, patterns of these costs track each other and MSRP trends (i.e., sharp decreases in per-vehicle costs during the initial standard setting years, with the rate of change plateauing in the later years of analysis across alternatives). Figure 8-20 breaks out the other cost and benefit components of the consumer net benefit calculation. Fluctuations in the effect on consumer surplus, refueling time cost, mobility benefits, and reallocated mileage values are relatively small compared to the decreases in retail fuel savings (expressed in the figure as increases in retail fuel outlay).

Figure 8-19: Light-Duty Vehicles MSRP-Based Incremental Consumer Costs, 3% Social Discount Rate

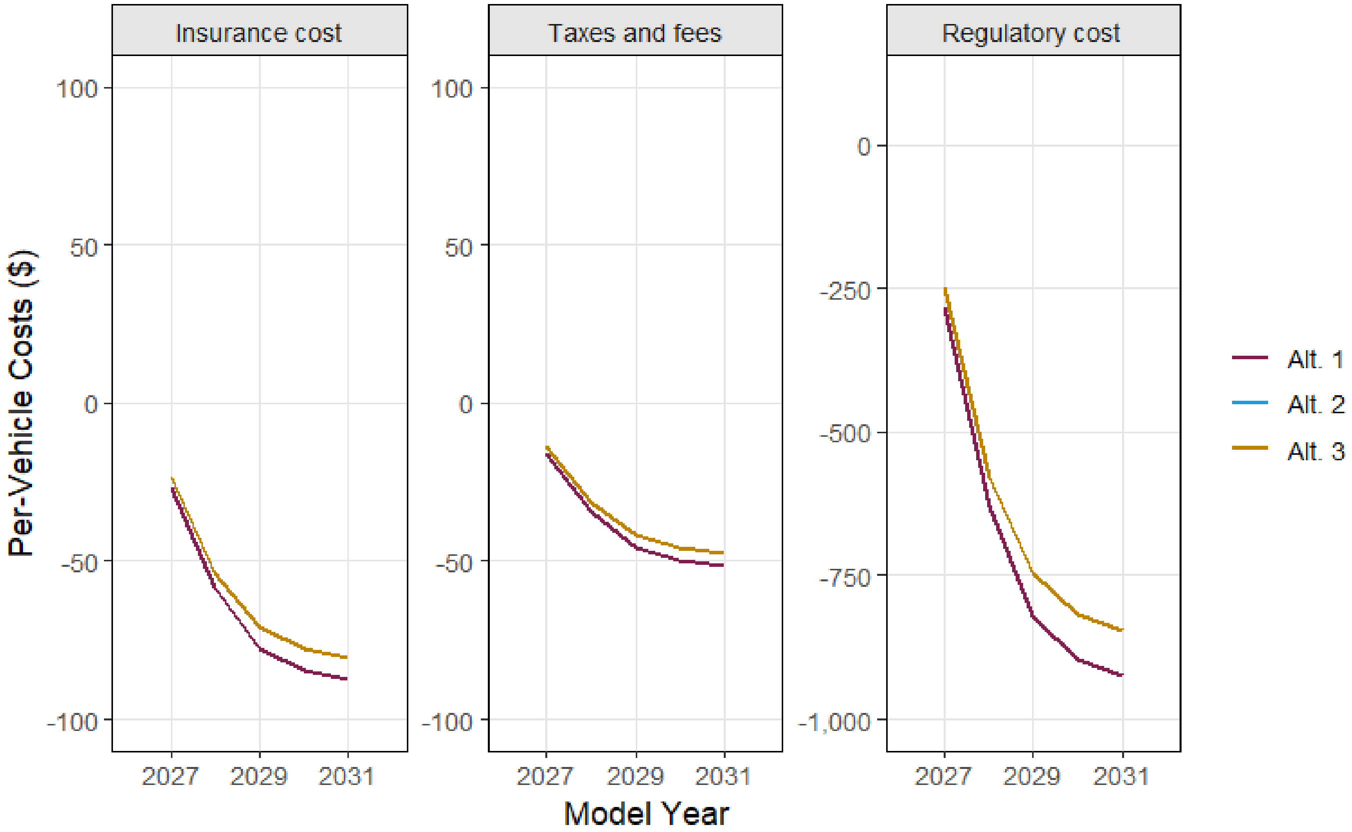
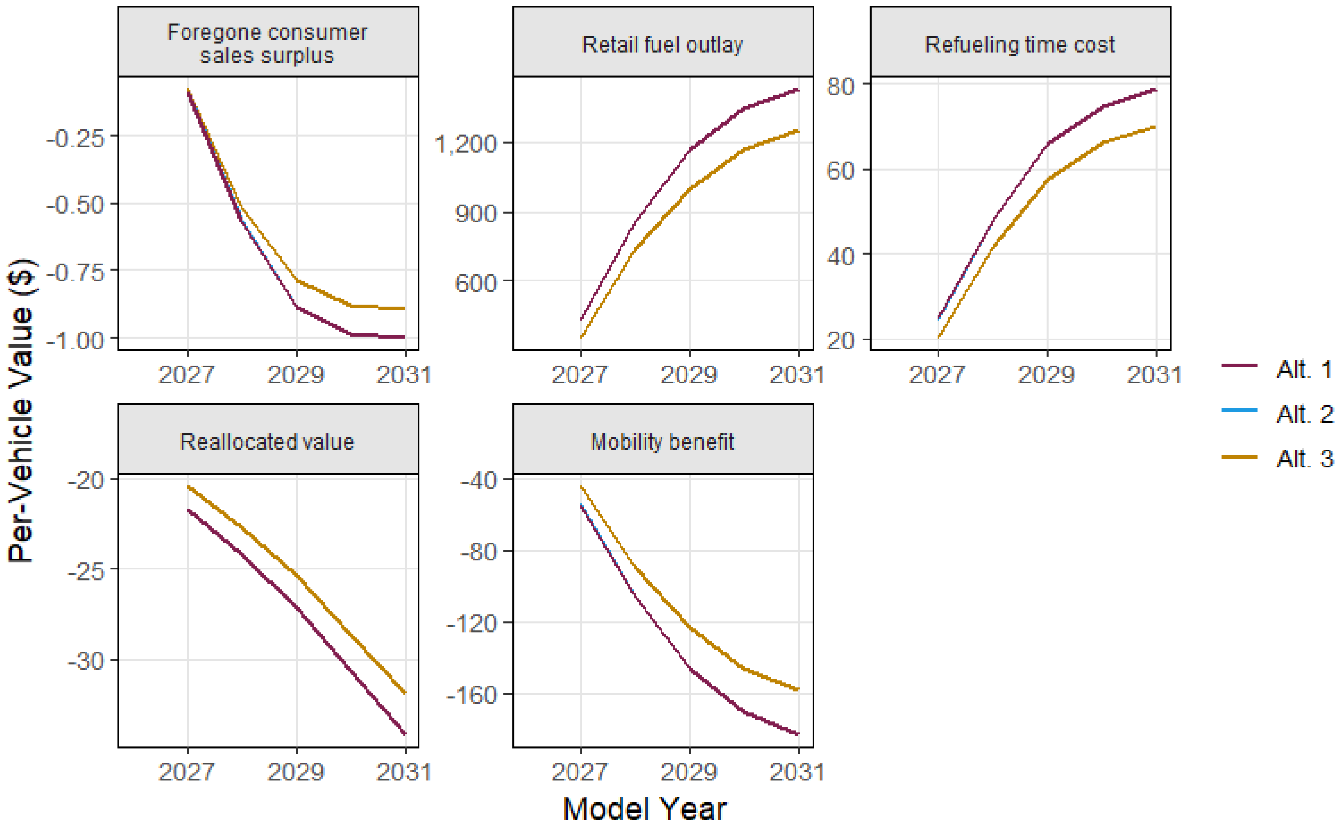


Figure 8-20: Light-Duty Vehicle Incremental Consumer Costs and Benefits, 3% Social Discount Rate



8.4. Effects on Society

This chapter discusses the benefits and costs to society at large associated with the different rulemaking alternatives, including external benefits and costs related to criteria pollutant emissions, congestion, noise, energy security, and safety. Chapter 0 summarizes the full accounting of both private costs and benefits (i.e., effects on manufacturers and consumers) described in the prior chapters and the societal costs and benefits described in this chapter.

The graphs in this chapter present certain effects in absolute terms, while others show incremental costs and benefits relative to the No-Action Alternative. Both model year and calendar year perspectives are used in this chapter depending on the effects discussed—particularly where the external nature of the cost or benefit more readily lends itself to a calendar year accounting structure.[132] Unless otherwise stated, the model year perspective includes MYs 1985-2031 and the calendar years that correspond to the full lifetimes of models produced in those model years (through CY 2070), while the calendar year perspective measures effects that accrue to the on-road fleet in CYs 2024-2050 only. This chapter presents effects over the lifetimes of vehicles regulated during the model years under consideration to illustrate the temporal differences in major cost and benefit components.

Figure 8-21 displays values for MYs 1985-2031 vehicles over their lifetimes, for all costs, including both private and social/external. For all alternatives and under both discount rates, costs and benefits are both negative, as measured against the baseline. Relative to the baseline, the three alternatives follow a very similar pattern of larger decreases in costs during CYs 2027-2031, reaching their greatest magnitude in 2030 or 2031. After 2032, the decreases in costs are lower than the decreases in benefits, which also reach their greatest magnitude in 2031. The largest decreases in costs accrue under Alternatives 1 and 2. The lowest reductions in benefits occur in Alternative 3.

[132] Chapter 5.3 of this PRIA explains the differences between calendar-year and model-year reporting.

Figure 8-21: Annual Costs and Benefits for MYs 1985-2031 (Total Fleet), on a CY Basis[133]

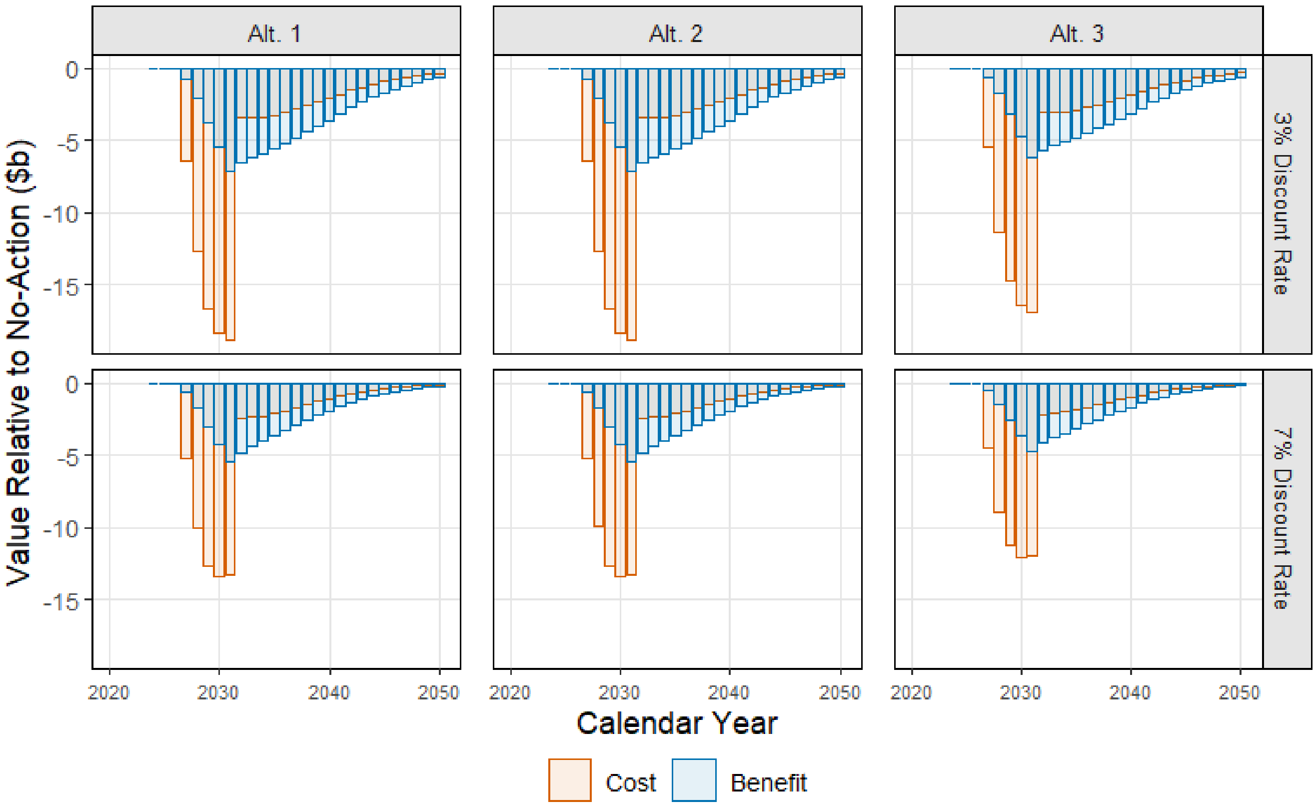
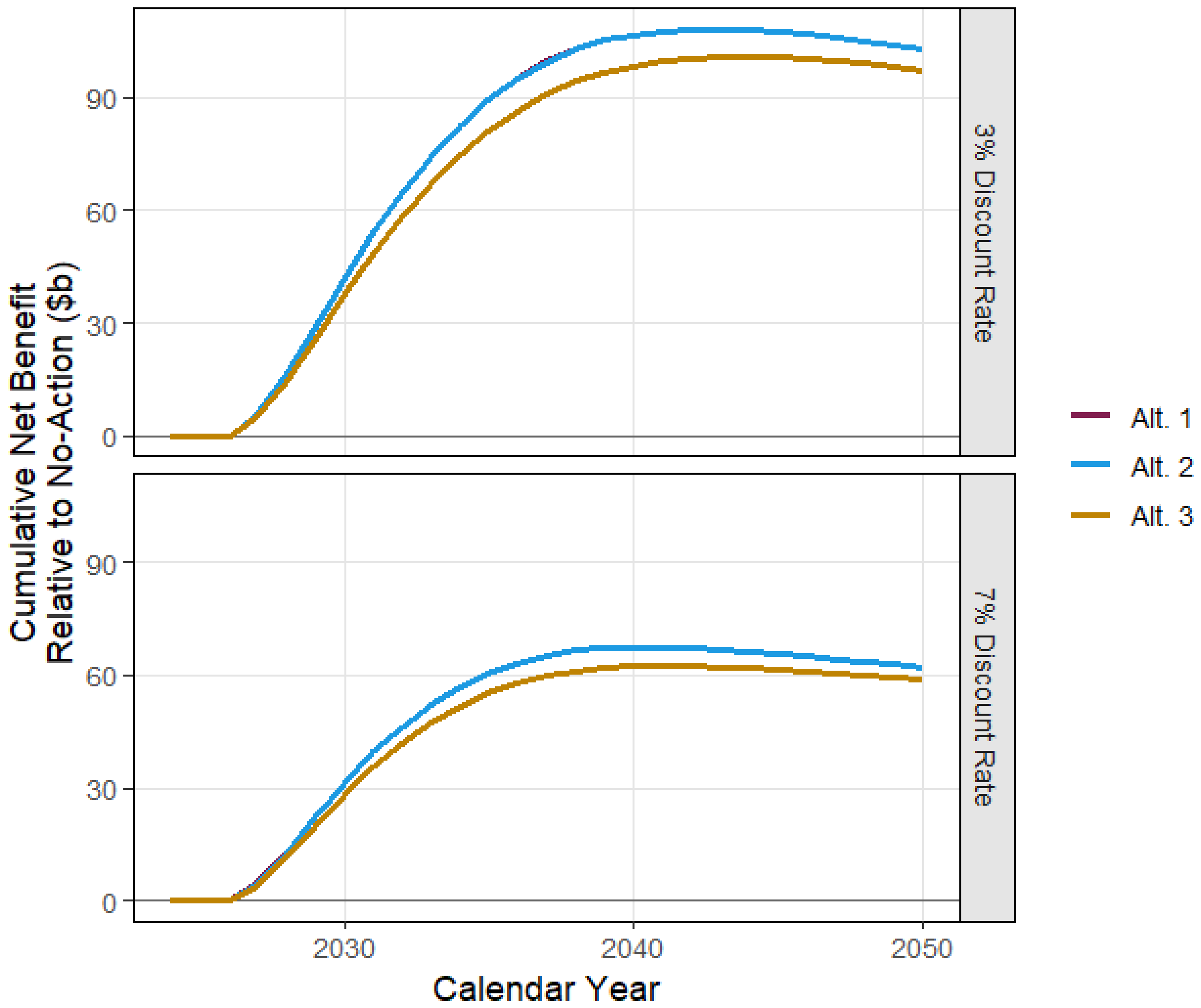


Figure 8-22 aggregates annual discounted cost and benefit streams to produce cumulative net benefits, by calendar year, for the three modeled alternatives from 2024 to 2050. Cumulative net benefits are positive for all alternatives at both discount rates and peak in the early 2040s under the 3-percent discount rate and in 2040 under the 7-percent discount rate before decreasing again. Alternative 1 is not visible on the graph due to its values closely tracking those of Alternative 2. Net benefits grow at a faster rate in earlier years than in later years. The cumulative net benefits are highest under Alternatives 1 and 2, under both the 3- and 7-percent discount rates.

[133] For exposition, the figure truncates costs and benefits at 2050. Some costs and benefits accrue out to 2071, though these values are relatively small.

Figure 8-22: Cumulative Net Benefits, CYs 2024-2050



8.4.1. Outcomes From Criteria Pollutant Emissions

The criteria pollutant emissions computed by the CAFE Model—NO_X and SO_X (via their contributions to the formation of particulate matter 2.5 microns or less in diameter ($PM_{2.5}$)),[134] and directly emitted $PM_{2.5}$—are linked to various health impacts (Draft TSD Chapter 5.4 provides more information).[135] The CAFE Model contains per-ton monetized health impact values corresponding to these health impacts (Draft TSD Chapter 6.2.2 provides more information). The CAFE Model calculates the total criteria pollutant emissions associated with the fleet in each alternative based on the emissions inventory discussed in Draft TSD Chapter 5, and the monetized health impact values per ton are then multiplied by the total tons in the emissions inventory. The resulting total costs associated with criteria pollutant emissions can be found in the CAFE Model Output Files.

In NHTSA's cost-benefit accounting, the monetized value reductions in pollutant emissions are captured as health benefits. Under the proposed standards, criteria pollutants emissions would increase relative to the baseline levels, resulting in some of those benefits being forgone.

[134] Though the health impacts of NO_X and SO_2 are associated with their contribution to secondarily formed $PM_{2.5}$, these are referred to as NO_X and SO_X health impacts throughout this chapter for simplicity and to show the origin of the pollution impacts.

[135] The morbidity health impacts included in the per-ton monetized values are acute bronchitis, asthma exacerbation, cardiovascular hospital admissions, lower respiratory symptoms, minor restricted activity days, non-fatal heart attacks, respiratory emergency room visits, respiratory hospital admissions, upper respiratory symptoms, and work loss days.

Table 8-4 shows the total and incremental health costs attributable to the three criteria pollutants under each rulemaking alternative, using the model year perspective (MYs 1985-2031), discounted at 3 and 7 percent. In the No-Action Alternative column, these costs are presented in absolute terms. Incremental costs for each action alternative are presented relative to the No-Action Alternative. These costs increase for all pollutants across all alternatives. The increases in costs are nearly identical in Alternative 1 and Alternative 2 but are slightly lower in Alternative 3. Increases in costs related to NO_X and $PM_{2.5}$ are significantly lower than the increases in costs for SO_X, which are the highest out of all the pollutants under all alternatives. Chapter 8.5.3, which describes the changes in pollutants emitted across alternatives (rather than the changes in costs), includes further explanation of these effects on a calendar year basis.

Table 8-4: Total and Incremental Costs of Criteria Pollutants, by Alternative and Social Discount Rate, MYs 1985-2031 (2024$, Millions)

	No-Action (Total)	Alt 1	Alt 2	Alt 3
3% Social Discount Rate				
NO_X	44,231	73.5	73.4	61.4
SO_X	67,723	722.5	721.8	622.5
$PM_{2.5}$	301,148	51.5	51.3	25.7
7% Social Discount Rate				
NO_X	33,223	42.2	42.1	35.2
SO_X	47,873	420.3	419.9	362.3
$PM_{2.5}$	210,955	34.0	33.9	19.3

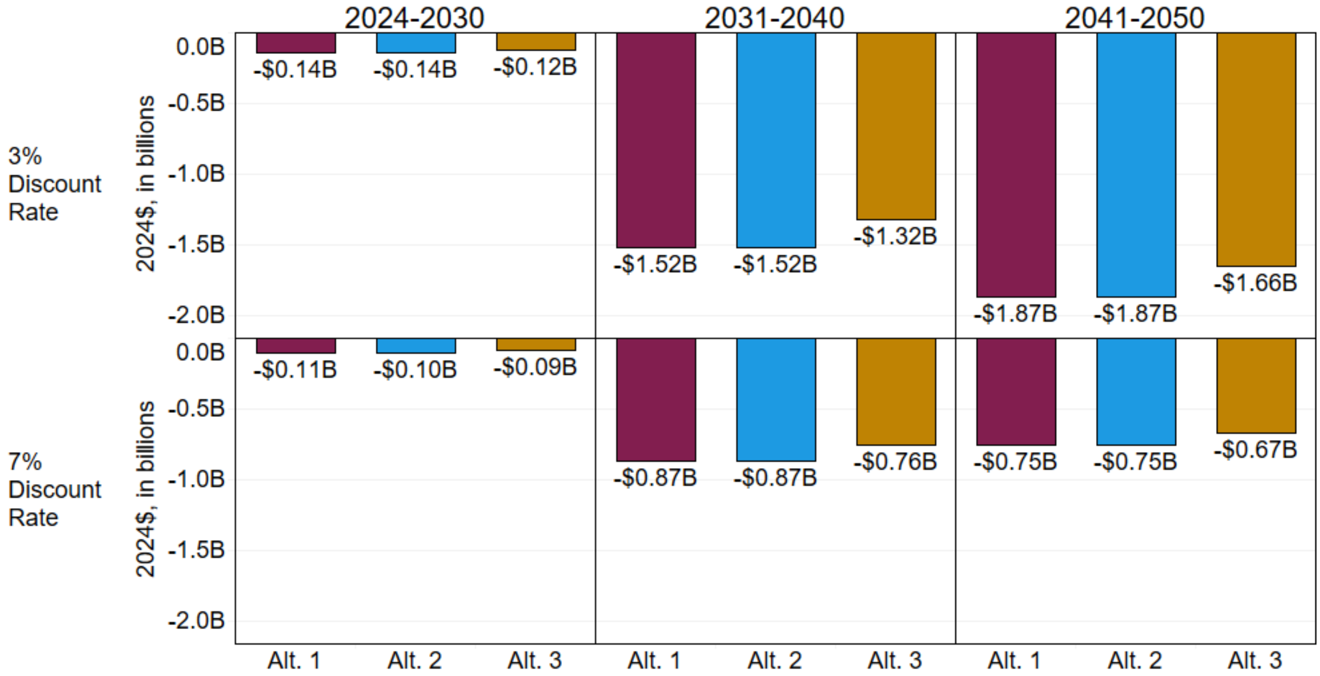
Figure 8-23 shows decreased benefits from an increasing level of criteria pollutants across the proposed alternatives and across calendar year cohorts, as opposed to across model year lifetimes. In terms of tons, NO_X has the highest magnitude of baseline emissions. However, the bulk of the criteria pollutant costs in dollar terms in the No-Action Alternative is due to direct $PM_{2.5}$ pollutants, which have more health costs per ton associated with them than NO_X and SO_X. In the No-Action Alternative, levels of all pollutants decrease across calendar years.

Relative to the No-Action Alternative, SO_X emissions result in the highest incremental costs in all three alternatives. The incremental increases in upstream emissions are higher for SO_X than for $PM_{2.5}$ upstream emissions, and the $PM_{2.5}$ tailpipe emissions decrease, whereas for SO_X they increase. SO_X tailpipe emissions increase relative to the No-Action Alternative because they are calculated based on fuel consumption, which increases relative to the No-Action Alternative. In contrast, VMT drives NO_x and $PM_{2.5}$ tailpipe emissions, which decrease relative to the No-Action Alternative.[136] These shifts tie back to the proposed standards, which have lower fuel economy requirements, leading to higher fuel use to drive the same amount of miles as in the baseline and lower VMT due to fewer rebound miles being driven in the alternatives.

As seen in the figure, the calendar year perspective shows that most of these reductions in benefits accrue in later years, from 2031 and beyond.

[136] See Chapter 5 in the Draft TSD for a discussion of the methodology through which some emissions are calculated based on fuel consumption (SO_2, CO_2) and others based on VMT.

Figure 8-23 Reductions in Health Benefits due to Increased Criteria Pollutants Relative to the No-Action Alternative (2024$, Billions, 3% and 7% Discount Rates, CYs 2024-2050)



8.4.2. External Costs of Changes in Congestion and Road Noise

Table 8-5 and Table 8-6 report the incremental social costs of congestion and noise relative to the totals in the No-Action Alternative across alternatives on a model year basis at 3- and 7-percent discount rates. Congestion and noise are functions of VMT, and therefore the reductions in these costs relate directly to decreases in VMT across model years and alternatives (see Chapter 8.2.4). Draft TSD Chapter 6.2.3 provides additional information regarding the calculation of congestion and noise costs in the CAFE Model and how these relate to VMT and other inputs. In the CAFE benefit-cost analysis framework, these costs are treated as external costs to society, not as benefits of avoiding congestion and noise. Overall, the trend across alternatives consists of small and relatively steady decreases in congestion and noise costs, with slightly greater magnitude decreases occurring in Alternatives 1 and 2.

Table 8-5: External Costs of Congestion and Noise Relative to No-Action Across Alternatives for MYs 1985-2031 (2024$, in Billions), Discounted at 3%

		Relative to the No-Action Alternative		
	No-Action (Total)	Alternative 1	Alternative 2	Alternative 3
Congestion	4,530	-9.50	-9.50	-8.44
Noise	43	-0.09	-0.09	-0.08

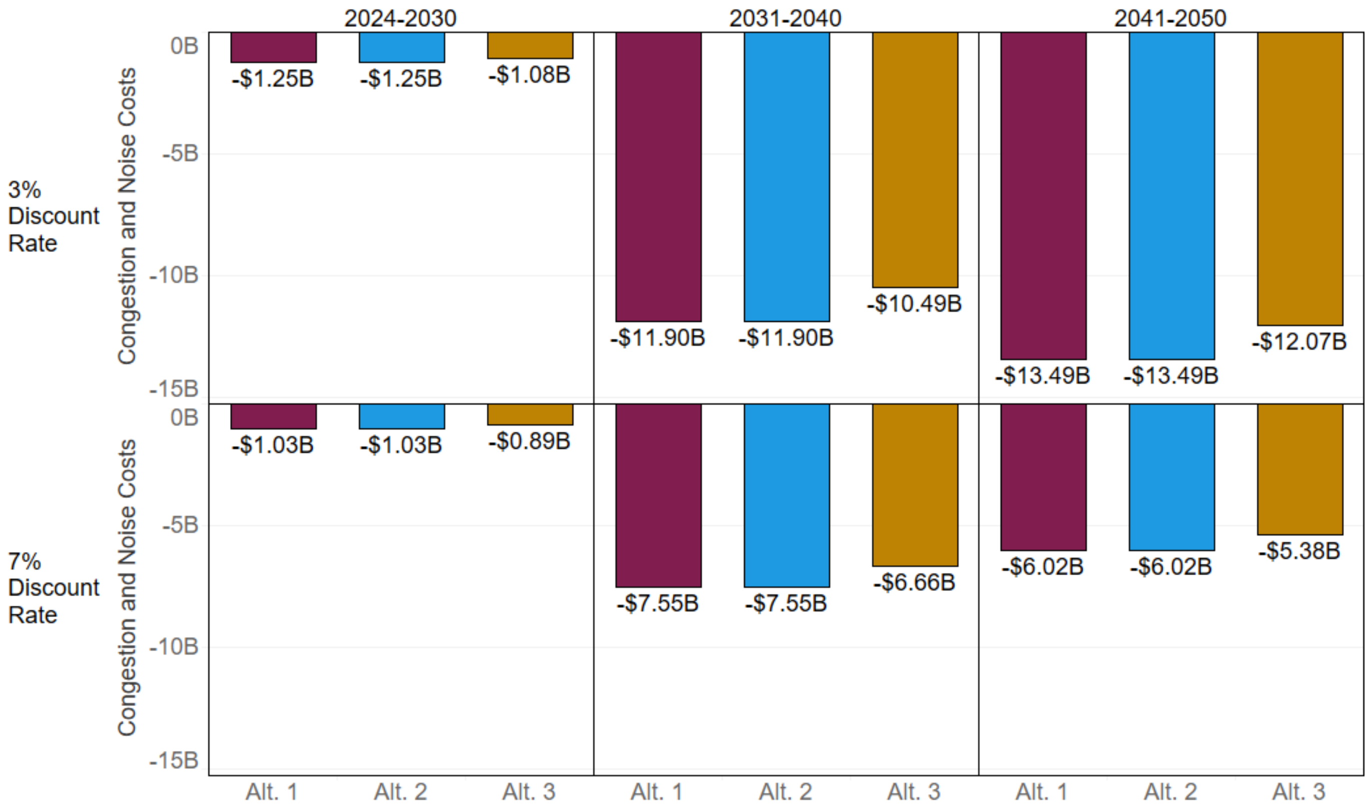
Table 8-6: External Costs of Congestion and Noise Relative to No-Action Across Alternatives for MYs 1985-2031 (2024$, in Billions), Discounted at 7%

		Relative to the No-Action Alternative		
	No-Action (Total)	Alternative 1	Alternative 2	Alternative 3
Congestion	3,488	-6.00	-6.00	-5.32
Noise	33	-0.06	-0.06	-0.05

Figure 8-24 shows differences in noise and congestion costs between the action alternatives relative to the No-Action Alternative and how the benefits of those reduced external costs are distributed across decades. Noise and congestion costs are combined due to the relatively small contribution of noise costs to the totals. In the top panel of Figure 8-24 (corresponding to the 3-percent discount rate), the bar corresponding to Alternative 2 in the period from 2041 to 2050 represents a $13.5 billion decrease in congestion and noise costs relative to the No-Action totals. Using a 3-percent discount rate, most of the incremental costs are incurred during the sixth decade, 2041-2050.

The incremental reduction in costs presented in Figure 8-24 are equal in value to a relatively small portion of the total congestion and noise costs incurred in the No-Action Alternative. For instance, under Alternative 2, using a 3-percent discount rate, the incremental reduction in costs arising from noise and congestion between 2041-2050 are equal in magnitude to less than 0.1 percent of the total congestion and noise baseline costs.

Figure 8-24: Reductions in Congestion and Noise Costs Relative to the No-Action Alternative, CYs 2024-2050 (2024$, Billions)



8.4.3. Reduction in Energy Security Benefits

The CAFE Model accounts for energy security benefits by computing changes in the costs of petroleum market externalities. These social costs represent the risk to the U.S. economy incurred by exposure to price shocks in the global petroleum market that are not internalized by consumers through long-run equilibrium gasoline prices. Changes in the costs of petroleum market externalities are a direct function of gallons of fuel consumed. Chapter 6.2.4 in the accompanying Draft TSD describes the methodology for calculating these petroleum market externality costs. Within the CAFE benefit-cost analysis framework, avoided petroleum market externalities are counted as energy security benefits.

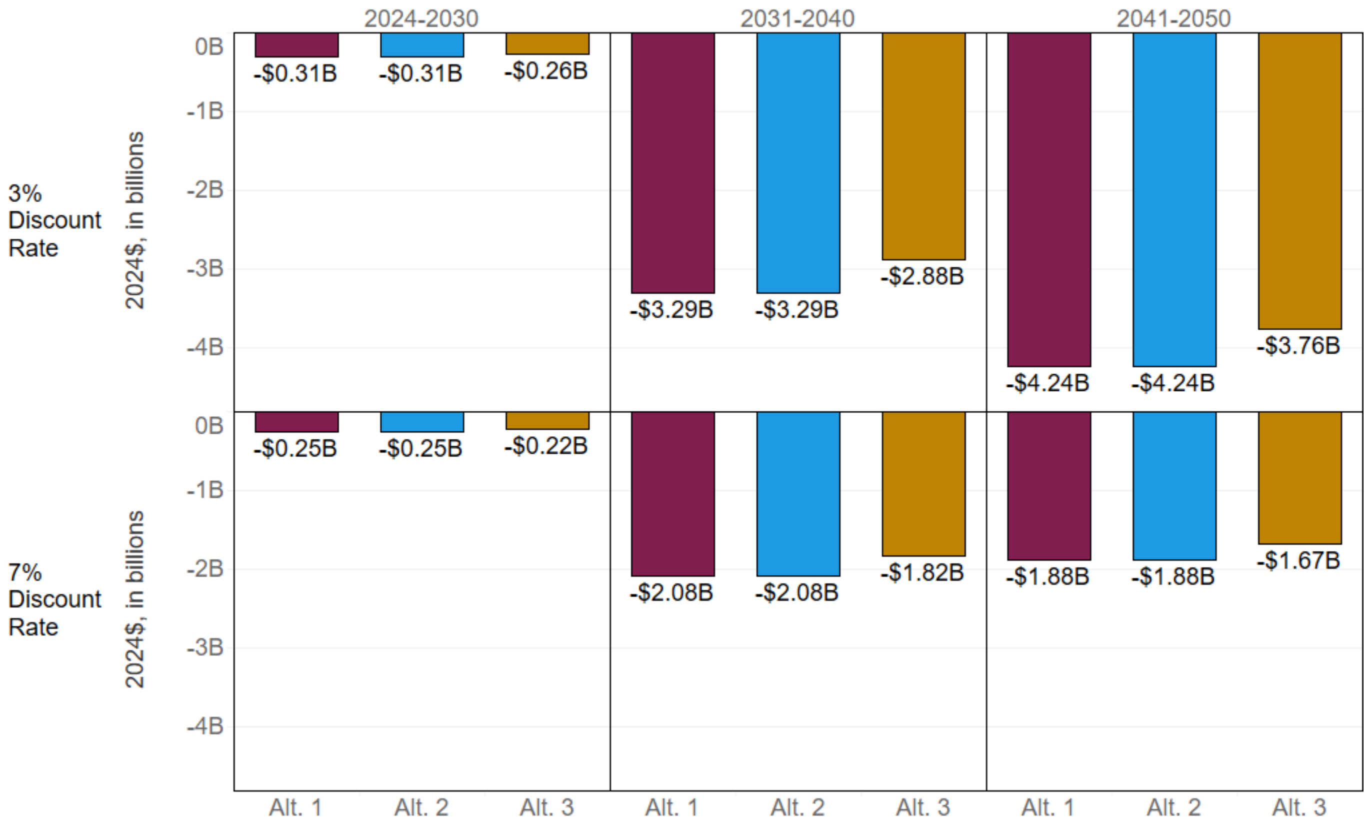
As seen in Table 8-7, the costs of petroleum market externalities increase (or the benefits of increased energy security decrease) in all alternatives, with the magnitudes of the increases becoming greater as the alternatives become less stringent. The scope of these changes is relatively small; using the 3-percent discount rate, the largest incremental change in these costs is approximately 1.3 percent of the total petroleum market externality costs in the No-Action Alternative.

Table 8-7: Social Costs of Increased Energy Security Relative to the No-Action Alternative, MYs 1985-2031 (2024$, Billions)

		Relative to the No-Action Alternative		
	No-Action (Total)	**Alternative 1**	**Alternative 2**	**Alternative 3**
3% discount rate	174.2	2.2	2.2	1.9
7% discount rate	133.3	1.4	1.4	1.2

Figure 8-25 shows the distribution of these costs (reduced benefits) across calendar year decades. Most of the decreases in benefits occur after the first decade, and the largest share of decreases corresponds to the period between 2041-2050, when the increases in fuel consumption are largest relative to the No-Action Alternative.

Figure 8-25: Reductions in Energy Security Benefits Relative to the No-Action Alternative, CYs 2024-2050 (2024$, Billions)



8.4.4. Safety Effects of Changing Standards

Table 8-8 through **Error! Reference source not found.** summarize the safety impacts of each alternative over CYs 2024-2050, broken down by safety factor, with monetized impacts presented under both 3- and 7-percent discount rates.[137]

Safety impacts are expected to be driven by (1) changes in vehicle mass resulting from vehicles having mass reduction applied to improve fuel economy; (2) decreased exposure via a reduction in rebound miles driven;

[137] Fatality, non-fatal injury, PDO counts are not monetized values and therefore are not discounted.

and (3) changes in fleet composition resulting from the impact of lower prices on new vehicle sales, as well as the relative desirability of passenger cars compared to light trucks.

Less stringent action alternatives exhibit less rebound driving because of the increase in driving costs. Lower prices resulting from resetting CAFE requirements as proposed would speed the turnover of the vehicle fleet. This results in more new vehicles being sold and fewer miles being driven in older vehicles that lack the improved safety features and technologies of newer vehicles.[138]

Across alternatives, mass changes relative to the No-Action Alternative result in small increases in overall fatalities, injuries, and property damage. This result reflects the estimated tendency for changes in mass either to have small, isolated or jointly offsetting effects on total fatalities. Changes in the mass of vehicles near the median of the distribution of curb weight have a relatively small effect on total fatalities, while broad upward shifts in vehicle mass lead to reductions in fatalities associated with the heaviest light trucks that are partially (but not fully) offset by increases in fatalities associated with relatively less mass increase in the lightest passenger cars.[139] Conversely, the rebound and scrappage effects from the regulatory alternatives lead to fewer fatalities and non-fatal injuries as policy alternatives become less stringent. The total decrease in societal crash costs range from $61.4 billion ($33.2 billion) to $68.4 billion ($37.3 billion) across alternatives with a 3-percent (7-percent) discount rate.

The magnitude of the rebound effect's impact on vehicle safety dominates the overall safety picture across the three alternatives, with changes in vehicle mass and sales/scrappage playing a minor role. As vehicles become safer, many crashes that would otherwise result in death or injury do not result in such harms, instead becoming property damage-only (PDO) crashes. An increase in sales/scrappage results in higher costs for PDOs.

Error! Reference source not found. Table 8-10 illustrates the cumulative impact of each alternative on the number of fatalities, non-fatal injuries, and vehicles sustaining property damage during CYs 2024-2050. For context, during this same period, fatalities in the No-Action Alternative are expected to total somewhat less than 370,000 or an annual average of about 14,000. The PDO outcomes for sales/scrappage are shown as a cost. This is a result of sale/scrappage effects being estimated as total PDO crashes minus rebound- and mass-attributed PDO crashes. The modeling system calculates PDO using a separate model from non-fatal and fatal crashes and then NHTSA accounts for rebound and mass-safety effects separately. Sales/scrappage PDO crashes are deemed to be the difference between total PDO crashes and PDO crashes attributable to either rebound driving or mass changes.[140]

Table 8-8: Change in Safety Costs From the No-Action Alternative (Reference Baseline) for CYs 2024-2050 for Total Fleet, 3% Discount Rate, by Alternative

Alternative	Alt 1	Alt 2	Alt 3
Fatality Costs ($b)			
Fatality Costs From Mass Changes	0.2	0.2	0.2
Fatality Costs From Rebound Effect Driving	-12.8	-12.8	-11.4
Fatality Costs From Sales/Scrappage	-0.7	-0.7	-0.7
Total - Fatality Costs	-13.4	-13.4	-11.9
Non-Fatal Crash Costs ($b)			
Non-Fatal Crash Costs From Mass Changes	0.8	0.8	0.6

138 Changes in the relative prices of cars and trucks result in changes in the sales of each through the CAFE Model's fleet share adjustment. Constrained non-rebound VMT is then reallocated between fleets, resulting in changes in the incremental safety effects for cars and light trucks. Because this is largely a function of the No-Action Alternative VMT being transferred between regulatory classes, much of this effect nets out at the light duty fleet level. Overall changes in vehicle safety are driven by vehicles that OEMs will produce farther in the future rather than vehicles produced in the nearer future.
139 As discussed in Draft TSD Chapter 7.3.3, the mass-safety parameters estimated from statistical models used in the CAFE analysis are statistically indistinguishable from zero.
140 Draft TSD Chapter 7.5 has additional details.

Non-Fatal Crash Costs From Rebound Effect Driving	-49.5	-49.5	-43.8
Non-Fatal Crash Costs From Sales/Scrappage	-1.6	-1.6	-1.6
Total - Non-Fatal Crash Costs	-50.3	-50.3	-44.8
Property Damage Costs ($b)			
Property Damage Costs From Mass Changes	0.1	0.1	0.1
Property Damage Costs From Rebound Effect Driving	-4.9	-4.9	-4.3
Property Damage Costs From Sales/Scrappage	0.2	0.4	0.4
Total - Property Damage Costs	-4.7	-4.7	-4.7
Societal Crash Costs ($b)			
Crash Costs From Mass Changes	1.1	1.1	0.8
Crash Costs From Rebound Effect Driving	-67.2	-67.2	-59.5
Crash Costs From Sales/Scrappage	-2.2	-2.0	-1.9
Total - Societal Crash Costs	-68.4	-68.4	-61.4

Table 8-9: Change in Safety Costs From the No-Action Alternative (Reference Baseline) for CYs 2024-2050 for Total Fleet, 7% Discount Rate, by Alternative

Alternative	Alt 1	Alt 2	Alt 3
Fatality Costs ($b)			
Fatality Costs From Mass Changes	0.1	0.1	0.1
Fatality Costs From Rebound Effect Driving	-6.9	-6.9	-6.1
Fatality Costs From Sales/Scrappage	-0.5	-0.5	-0.5
Total - Fatality Costs	-7.3	-7.3	-6.5
Non-Fatal Crash Costs ($b)			
Non-Fatal Crash Costs From Mass Changes	0.4	0.4	0.3
Non-Fatal Crash Costs From Rebound Effect Driving	-26.6	-26.6	-23.5
Non-Fatal Crash Costs From Sales/Scrappage	-1.3	-1.3	-1.2
Total - Non-Fatal Crash Costs	-27.5	-27.5	-24.4
Property Damage Costs ($b)			
Property Damage Costs From Mass Changes	0.0	0.0	0.0
Property Damage Costs From Rebound Effect Driving	-2.7	-2.7	-2.4
Property Damage Costs From Sales/Scrappage	0.1	0.1	0.1
Total - Property Damage Costs	-2.6	-2.6	-2.3
Societal Crash Costs ($b)			
Crash Costs From Mass Changes	0.5	0.5	0.3
Crash Costs From Rebound Effect Driving	-36.1	-36.1	-31.9

Crash Costs From Sales/Scrappage	-1.7	-1.7	-1.7
Total - Societal Crash Costs	-37.3	-37.3	-33.2

Table 8-10: Change in Safety Parameters From the No-Action Alternative (Reference Baseline) for CYs 2024-2050 for Total Fleet, by Alternative

Alternative	Alt 1	Alt 2	Alt 3
Fatalities			
Fatalities From Mass Changes	27	27	20
Fatalities From Rebound Effect Driving	-1,528	-1,528	-1,354
Fatalities From Sales/Scrappage	-66	-66	-64
Total - Fatalities	-1,568	-1,567	-1,398
Non-Fatal Injuries			
Non-Fatal Injuries From Mass Changes	4,264	4,264	3,221
Non-Fatal Injuries From Rebound Effect Driving	-245,022	-244,963	-217,158
Non-Fatal Injuries From Sales/Scrappage	-5,709	-5,709	-5,564
Total - Non-Fatal Injuries	-246,467	-246,408	-219,501
Property Damage Crashes			
Property Damage Crashes From Mass Changes	13,629	13,629	10,379
Property Damage Crashes From Rebound Effect Driving	-835,103	-834,915	-740,855
Property Damage Crashes From Sales/Scrappage	26,991	26,989	25,437
Total - Property Damage Crashes	-794,482	-794,297	-705,039

8.5. Physical Effects

As explained in previous sections, changes to vehicle fuel economy, and subsequently vehicle prices, will influence the composition of the fleet. Table 8-11 shows the projected cumulative effects of the proposal to the on-road fleet population, total VMT, and the quantity of fuel consumed over the next three decades for each alternative. The analysis begins with MY 2024, so the first interval covers CYs 2024-2030, while the latter two intervals each encompass effects over 10 years. As such, the values shown for the first calendar year grouping are marginally lower (by comparison) than what they would have been if the entire 10-year horizon were available. Nevertheless, the cumulative impacts are presented to provide a reader with a snapshot of the overall results of the analysis, while also demonstrating the relative differences between calendar year groups. The following subchapters explore the effects at a more granular level, presenting this information in a disaggregated manner by focusing on the effects during individual calendar years.

Table 8-11: Cumulative Physical Effects for Each Alternative

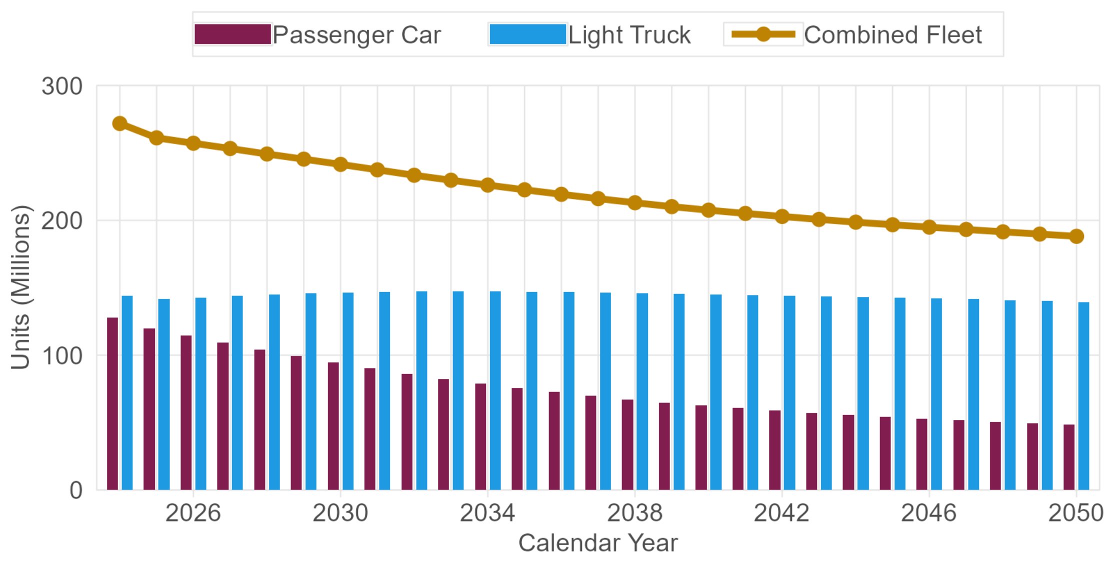
	No-Action	Alt 1	Alt 2	Alt 3
	On-Road Fleet (Million Units)			
2024-2030	1759.6	1759.4	1759.4	1759.5
2031-2040	2,215.7	2,218.2	2,218.2	2,218.1
2041-2050	1,984.2	1,989.9	1,989.9	1,989.6

	Vehicle Miles Traveled (Billion Miles)			
2024-2030	21,576.6	21,564.7	21,564.7	21,566.3
2031-2040	27,764.0	27,623.2	27,623.2	27,640
2041-2050	25,271.3	25,061.1	25,061.1	25,083.5
	Fuel Consumption (Billion Gallons/GGE)			
2024-2030	879.6	882.7	882.7	882.3
2031-2040	952.9	989.7	989.6	985.1
2041-2050	766.0	822.3	822.3	816.0

8.5.1. Changes to the On-Road Fleet and Vehicle Miles Traveled

Figure 8-26 presents the size of the on-road fleet through CY 2050 under the No-Action Alternative. The vertical bars in the figure denote the annual volume of the passenger car and light truck fleets, while the line above the bars plots the size of the combined fleet. NHTSA projects a long-term decline in the total sales of gasoline- and diesel-powered vehicles (the only vehicle types considered in this analysis) in the No-Action Alternative. Figure 8-26 shows that the overall fleet in the baseline experiences a significant decline through CY 2050, as fewer new internal combustion engine (ICE) vehicles are added to the fleet and older ICE vehicles are retired. Details about how NHTSA projects new vehicle sales and vehicle retirements can be found in Draft TSD Chapter 4.

Figure 8-26: Total On-Road Fleet in the No-Action Alternative



The light truck and passenger car volumes are reported in Figure 8-26 in accordance with current (i.e., not proposed) vehicle classification regulations. The production of light trucks (9.41 million units) is more than double the production of passenger cars (4.30 million units) in the MY 2024 reference fleet. The share of light trucks as a part of the entire fleet grows throughout the analysis since new vehicle sales are increasingly skewed towards light trucks. By the end of the analysis (MY 2050), the volume of new light trucks sold (7.50m units) is estimated to be triple the volume of passenger cars sold (2.54m units). The surplus of light truck sales, coupled with the accompanying decline in passenger car shares and the retirement of the existing fleet, leads to this sharp shift in the on-road fleet from passenger cars to light trucks.

A similar trend can be observed in VMT projections in the No-Action Alternative as illustrated in Figure 8-27.[141] Because the No-Action Alternative represents the state of world in the absence of this proposed rulemaking, this figure shows VMT under the current vehicle classification regulations. Due to the overall decline in gas-powered vehicle sales and subsequent contraction of the gas-powered vehicle fleet, the total amount of VMT driven by the combined fleet is also expected to decrease year over year. This decline is particularly pronounced in the passenger car fleet, as miles that were driven in the earlier calendar year in passenger cars gradually shift towards more miles being driven in light trucks. VMT for the light truck fleet initially grows slightly during this transition before decreasing slightly in the later years. By 2050, the share of total miles traveled by the light truck fleet is projected to be more than twice as high as that of the passenger car fleet.

Figure 8-27: Total VMT in the No-Action Alternative

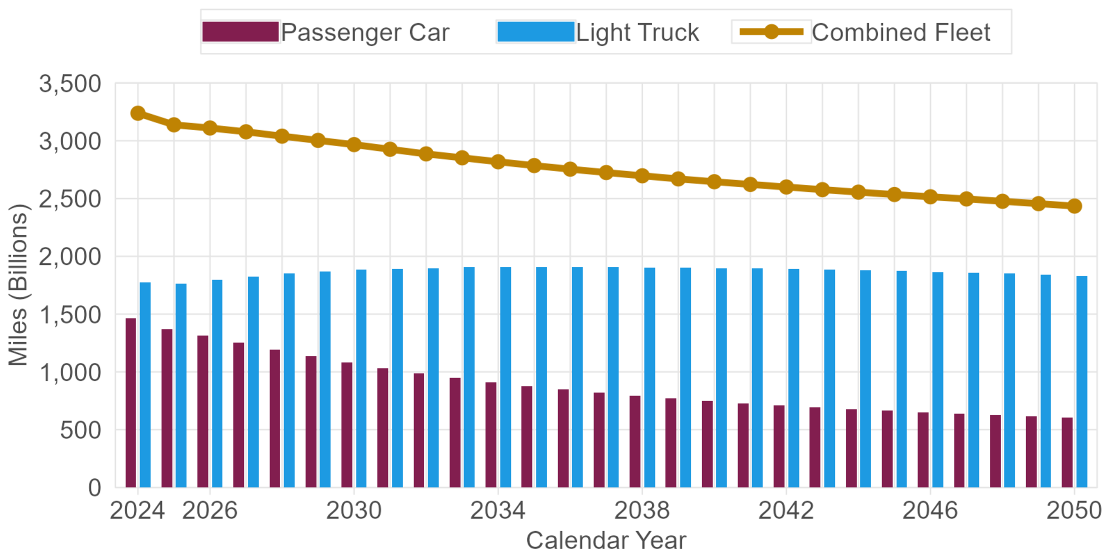


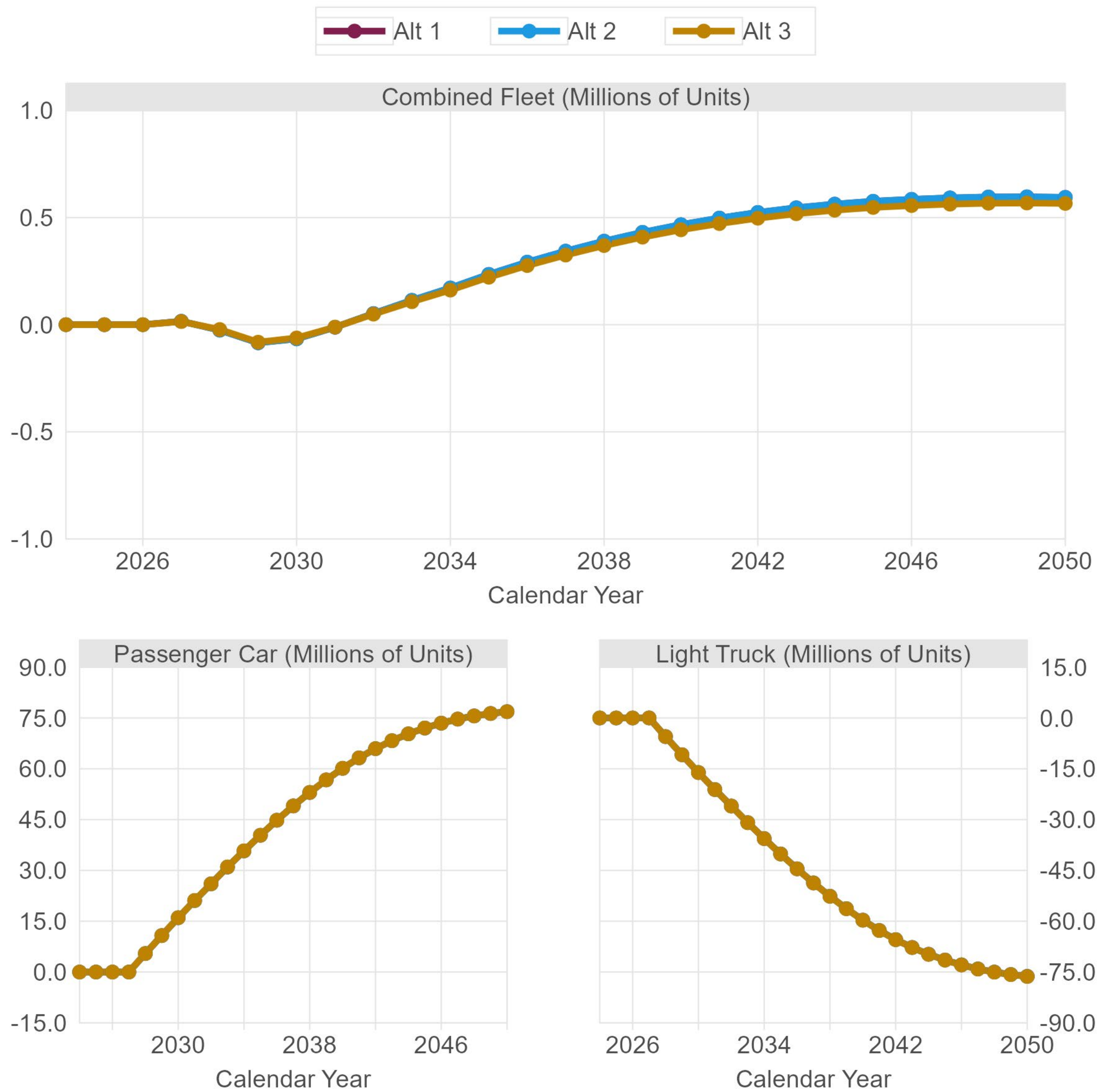
Figure 8-28 presents the change in fleet size for each action alternative relative to the No-Action Alternative. In general, total fleet size increases under all alternatives considered because each alternative sees increases in new vehicle sales, relative to the No-Action baseline, due to lower regulatory costs and vehicle prices. The respective increases and decreases in the individual passenger car and light truck fleets are caused primarily by fleet reclassification in the action alternatives starting in 2028 and are only marginally impacted by changes to fleet share induced by the action alternatives.[142]

In Figure 8-28 (and other figures in Chapter 8), the differences between some alternatives are too small to distinguish visually. Note that the values in the axes vary between figures and tables to illustrate better the differences across alternatives.

[141] The agency breaks VMT into two components: "non-rebound VMT" and "rebound VMT." Non-rebound VMT is assumed to be unaffected by the standards, because much of the demand of travel is presumed to be inelastic and therefore is the same across all regulatory scenarios. Rebound VMT is the direct measurement of how demand for VMT will respond to decreases in vehicle operating costs. See Draft TSD Chapter 4.3. Since non-rebound VMT is fixed across alternatives, rebound VMT is responsible for the changes in VMT across alternatives.

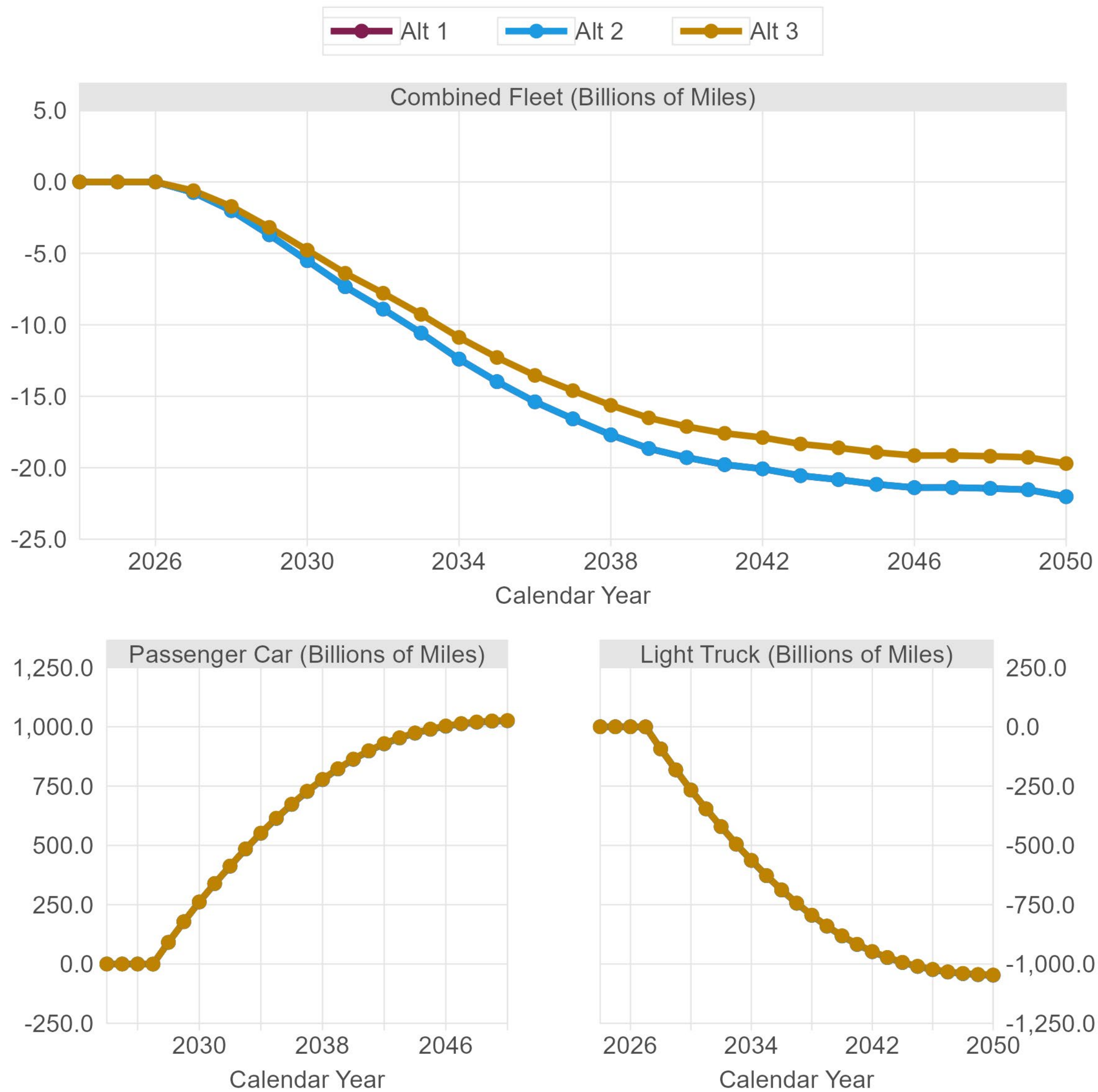
[142] For an estimate of fleet effects with reclassification in the baseline, or without reclassification in the action alternatives, see PRIA Chapter 9.2.5.

Figure 8-28: Changes in On-Road Fleet Compared to the No-Action Alternative



Despite the volume of the on-road fleet increasing slightly in the action alternatives, the total miles traveled by the entire fleet decreases compared to the No-Action Alternative. VMT is reduced because the newer vehicles sold in the action alternative have a higher cost to operate due to reduced fuel economy and therefore are driven less because of the rebound effect. Figure 8-29 illustrates the incremental differences in VMT for each calendar year between the action alternatives and the reference baseline scenario.

Figure 8-29: Changes in VMT Compared to the No-Action Alternative

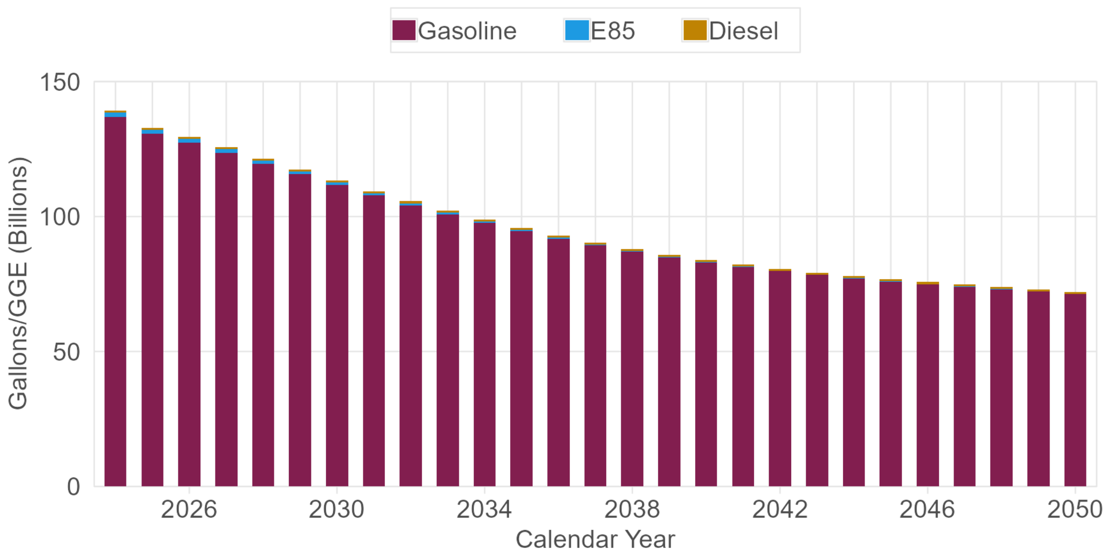


Alternatives 1 and 2 experience a slightly larger decline in total miles because they see a larger resetting of standards and the fleets are less fuel efficient than Alternative 3 and the No-Action baseline. However, the total change in VMT is 0.5 percent in Alternative 2 from the No-Action Baseline over the analysis period. VMT decreases the least under the most stringent action alternative, Alternative 3, as the cost of driving is nearest to that of the No-Action Alternative. Changes in VMT between the passenger car and light truck fleets derive from changes in their respective fleet volumes as a result of reclassification. Note that Alternatives 1 and 2 are on top of each other in the top panel, and all three action alternatives overlap in the bottom two panels.

8.5.2. Changes to Fuel Consumption and Non-Criteria Emissions

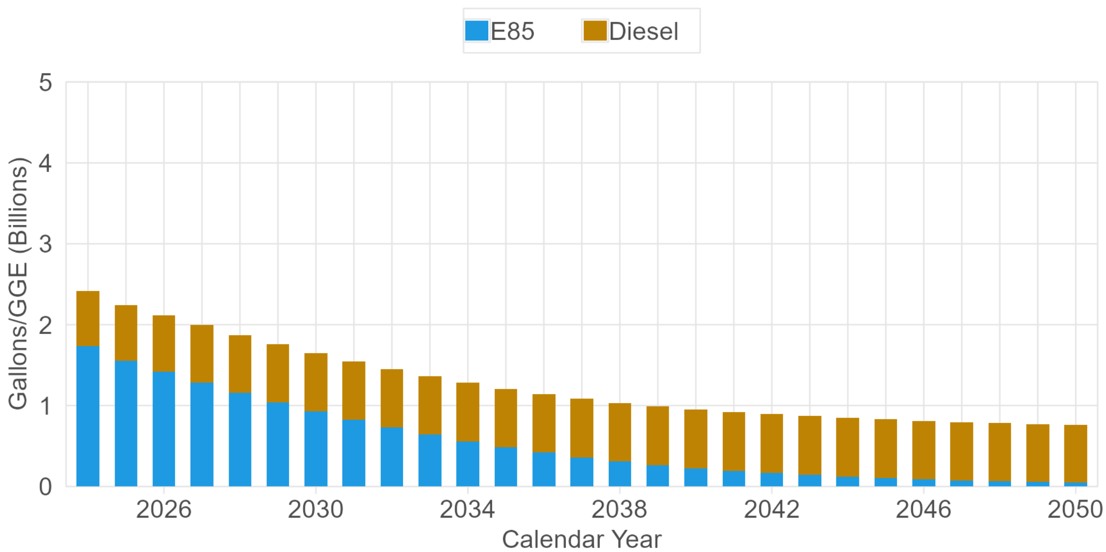
Changes in CAFE standards impact the total amount of fuel consumed by altering the cost per mile of driving and influencing the displacement of older and less efficient vehicle models through sales and scrappage effects. With the existing fleet gradually turning over with each subsequent calendar year, the effects of standards during earlier model years become increasingly evident, influencing the annual fuel consumption of the U.S. vehicle fleet. Figure 8-30 presents the consumption of various fuel types in each calendar year for the No-Action Alternative.[143]

Figure 8-30: Fuel Consumption in the No-Action Alternative



As illustrated by Figure 8-30, gasoline remains the main source of fuel for ICE vehicles well into the future under the No-Action Alternative and the collective sum of all the other alternative fuel types used by the on-road fleet is only a fraction of the total energy consumed during each calendar year.[144] Figure 8-31 provides a closer look at the consumption of non-gasoline fuels. This figure shows the use of diesel remains relatively constant and the use of E85 steadily declines.

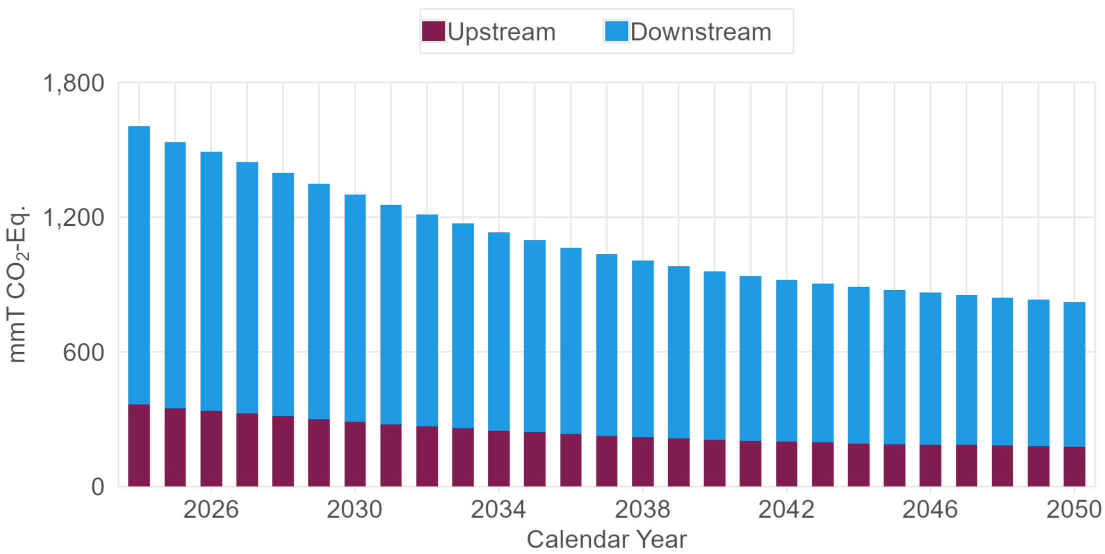
Figure 8-31: Consumption of Non-Gasoline Fuels in the No-Action Alternative



[143] Note that all effects from BEVs and FCEVs are excluded from NHSTA's analysis.
[144] In CY 2024, the total amount of E85 and diesel fuels consumed by the on-road fleet is 1.7 percent in the No-Action Alternative. By CY 2050, that number declines to 1.1 percent. Some vehicles in the Market Data Input File include a 0.01 fuel share input for E85 usage, which is why E85 shows up in these results; however, in accordance with 49 U.S.C. 32902(h), NHTSA plans to change the E85 fuel share to 0 for the final rule.

Because the consumption of fuel by the fleet directly releases CO_2, changes in overall energy consumption also result in changes in emissions of CO_2. Emissions of CH_4 and N_2O are affected as well.[145] Figure 8-38 displays the amount of annual CO_2, CH_4, and N_2O (non-criteria emissions (NCEs)) generated by the light duty fleet under the No-Action Alternative. In the figure, the emissions of CO_2, CH_4, and N_2O are combined using a cumulative total. The amount of CO_2 is measured using million metric tons (mmT), while emissions coming from CH_4 and N_2O are scaled by the GWP multipliers of 25 and 298, respectively,[146] and are denominated using mmT of CO_2-equivalent emissions. This analysis does not include HFC emissions from vehicles.

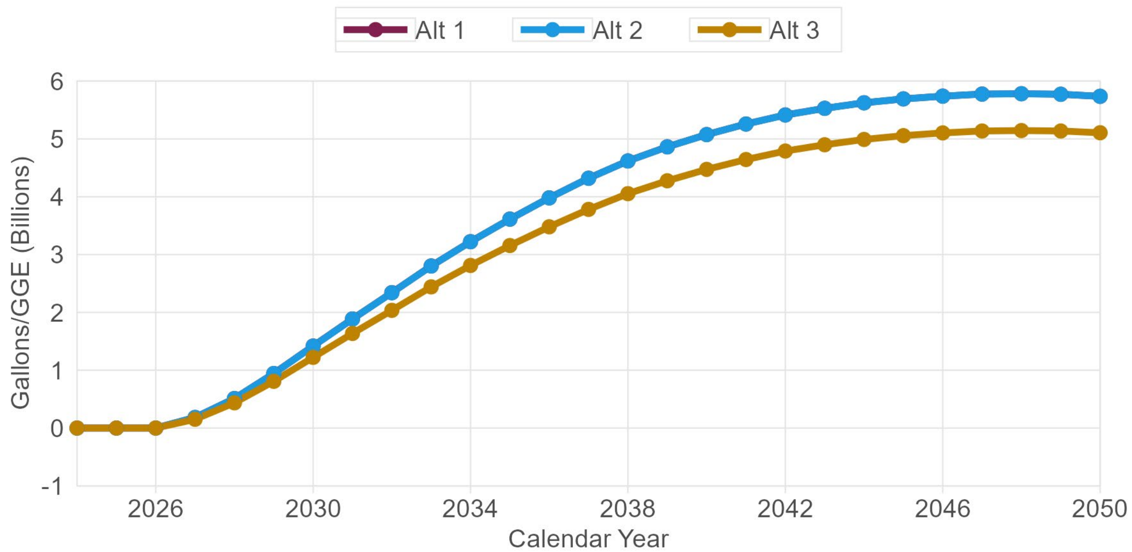
Figure 8-32: Non-Criteria Emissions in the No-Action Alternative



Fleetwide fuel consumption rises in response to resetting CAFE standards under the action alternatives. Figure 8-33 presents the incremental differences to overall energy consumption for each action alternative as compared to the No-Action Alternative. As shown in the figure, the amount of fuel consumed by the on-road light duty fleet depends on the difference in CAFE standard stringency between each alternative and the No-Action Alternative. There is little variation in incremental fuel use between Alternatives 1 and 2, thus the lines lie on top of each other in the figure.

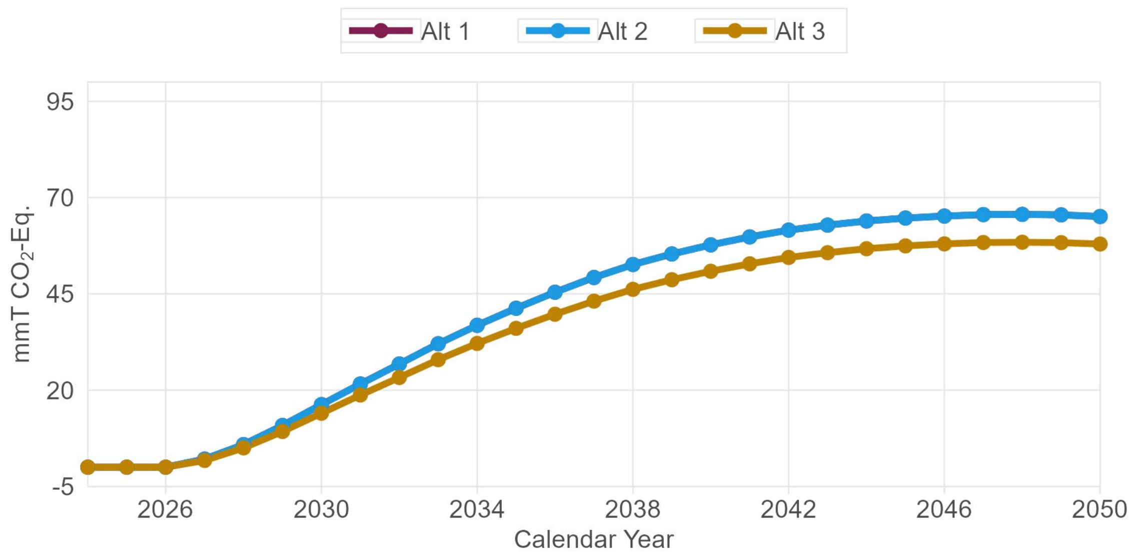
[145] Quantities of emissions of CO_2, CH_4, and N_2O are reported in this section but are not monetized and do not enter the calculation of total benefits or costs associated with the regulatory alternatives, as presented in Table 8-14 and Table 8-15.
[146] See the SAFE rule for a discussion of how GWP multipliers are derived. NHTSA calculates emissions of CH_4 and N_2O directly in terms of tons emitted.

Figure 8-33: Changes in Fuel Consumption Compared to the No-Action Alternative



Because resetting the CAFE standards increases fuel consumption, CO_2, CH_4, and N_2O emissions from the on-road fleet rise under each action alternative. Figure 8-39 presents the incremental changes to these emissions as compared to the No-Action Alternative. In each case, the incremental emissions of non-criteria pollutants increase at a decreasing rate as the standards defined by the action alternatives decrease in stringency. Hence, the highest CAFE standards, defined by Alternative 3, lead to the smallest increase in upstream, downstream, and overall emissions of CO_2, CH_4, and N_2O. Note that Alternatives 1 and 2 are extremely similar in outcomes, thus the two lines lie on top of each other and obscure Alternative 1 in the figure.

Figure 8-34: Changes in Non-Criteria Emissions Compared to Reference Baseline



8.5.3. Changes to Criteria Air Pollutant Emissions

This chapter presents changes in emissions for a subset of criteria air pollutants supported by the CAFE Model, specifically upstream and downstream emissions related to NO_X, SO_X, and $PM_{2.5}$. Similar to previous figures, the differences in emission volumes between Alternatives 1 and 2 may be too small to distinguish visually. The health outcomes resulting from exposure to these pollutants are discussed in Chapter 8.5.4.

Figure 8-35 and Figure 8-36 present annual upstream and downstream emissions of NO_X and $PM_{2.5}$, respectively, under the standards defined by the No-Action Alternative. In the case of $PM_{2.5}$, downstream emissions are split and presented separately for emissions related to brake and tire wear (BTW) and vehicular emissions originating at a vehicle's exhaust.[147] As older vehicles are retired and gas-powered fleet volume and VMT decrease, a rapid decline of NO_X and $PM_{2.5}$ downstream emissions can be seen from both figures.

The relative impacts from upstream emissions for both pollutants are comparatively less pronounced, however, showing some fluctuation in the No-Action Alternative, but ultimately resulting in a marginal decrease due the expected reduction in fuel consumption in the baseline. As such, Figure 8-35 and Figure 8-36 show a marginal annual decrease to the upstream emissions of NO_X and $PM_{2.5}$.

Figure 8-35: Emissions of NO_X in the No-Action Alternative

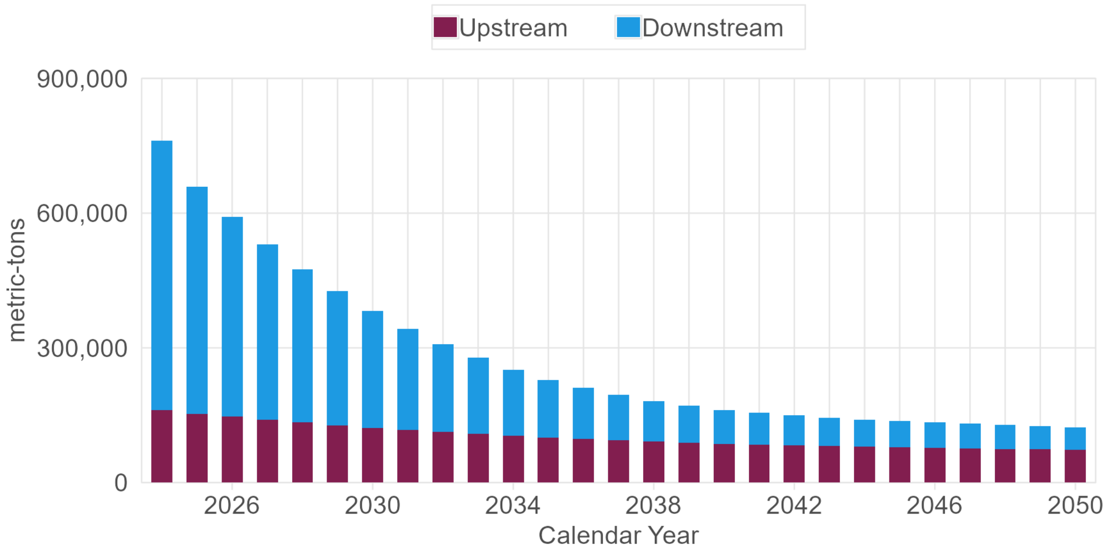


Figure 8-36: Emissions of $PM_{2.5}$ in the No-Action Alternative

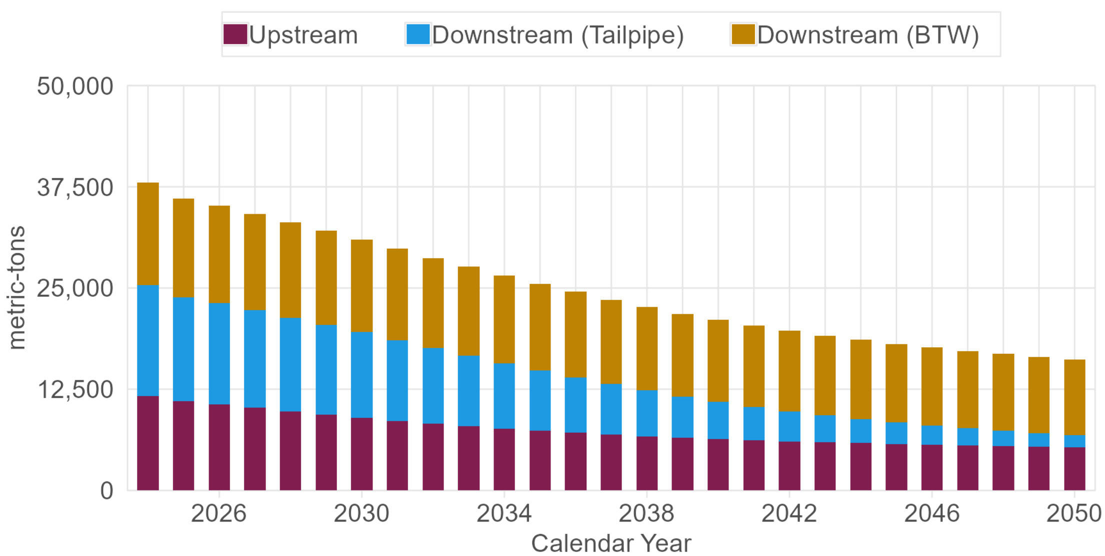
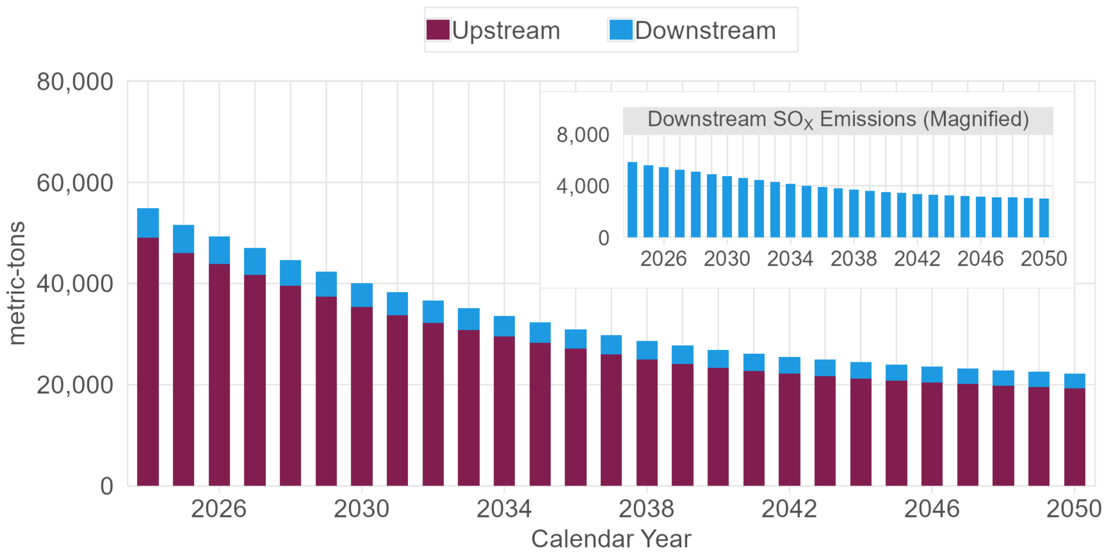


Figure 8-37 shows the annual SO_X emissions for the on-road fleet under the No-Action Alternative. Unlike the previous two pollutants, downstream emissions of SO_X are measured based on the consumption of fuel rather

[147] NHTSA has introduced separate accounting of $PM_{2.5}$ BTW emissions that varies by regulatory class into the analysis for the current rulemaking. See Draft TSD Chapter 5.3 for a description of how emission factors were generated.

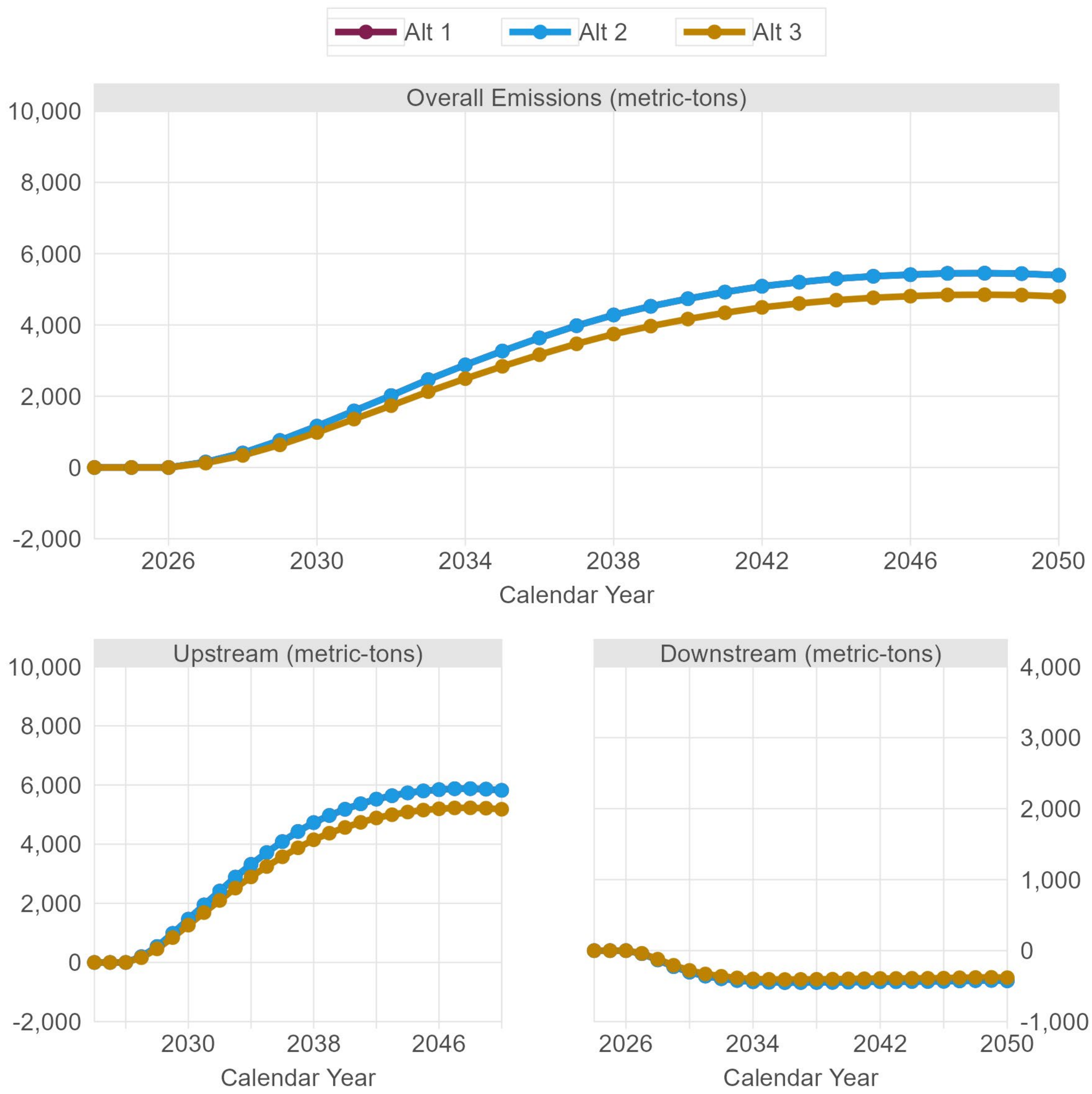
than on a per-mile basis dictated by the vehicle emissions standards. This means SO_X emissions are influenced directly by changes to the amount of fuel consumed rather than the total miles traveled by the light duty fleet. Figure 8-37 shows that the downstream component provides a marginal contribution to overall SO_X emissions and generally undergoes a downward trend as fuel consumption decreases. The inner plot in the top-right corner of the figure presents a magnified view of downstream SO_X emissions for clarity. Upstream SO_X emissions see a mostly similar pattern as was observed for NO_X and $PM_{2.5}$ pollutants.

Figure 8-37: Emissions of SO_X in the No-Action Alternative



As demonstrated in the next several figures, changes in CAFE standards generally lead to changes in both upstream and downstream emissions of NO_X, SO_X, and $PM_{2.5}$ for all action alternatives. The net changes to total emissions are consistently positive across all figures, though changes to downstream emissions depend on the pollutant being discussed. Figure 8-38 shows the incremental changes to NO_X emissions in the action alternatives versus the No-Action Alternative. The larger chart at the top presents the overall emissions of NO_X, while the left and right portions at the bottom provide separate views of upstream and downstream components, respectively. This shows that NO_X emissions generally increase with the changes in CAFE standards across alternatives.

Figure 8-38: Changes in NO_X Emissions Compared to the No-Action Alternative



The downstream emissions in Figure 8-38 show a net decrease under all action alternatives as compared to the No-Action Alternative. The upstream emissions for the most stringent alternative (Alt 3) show an increase over the No-Action Alternative beginning in the standard setting years as the demand for gasoline rises. The difference in directionality between upstream and downstream emissions of NO_X is caused by changes to the amount of fuel consumed and VMT across the alternatives. Downstream emissions are estimated as a function of VMT, while upstream emissions are estimated as a function of fuel production volumes.[148] The decreasing stringency of standards causes a decrease in VMT that induces a decrease in downstream emissions. In addition, greater fleet turnover in the action alternatives leads to newer vehicles, which have lower emission rates than older vehicles, handling a greater share of travel. However, due to the lower fuel economy of the on-road fleet, the analysis shows an increase in fuel demand, which induces an increase in upstream emissions. In total, the increase in upstream emissions caused by an increase in the demand for fuel is greater than the reduction in downstream emissions caused by reduced VMT, causing a net increase in NO_X across action alternatives.

Figure 8-39 presents the incremental changes to $PM_{2.5}$ emissions in the action alternatives as compared to the No-Action Alternative. The upstream and downstream emissions trends for $PM_{2.5}$ criteria air pollutants are

[148] Readers should refer to the Parameters Input File for the current assumptions of the annual downstream emission inputs for various pollutants.

similar to that of NO_X and also have the same underlying root causes for the observed behavior. In the case of $PM_{2.5}$, the downstream portion represents a combination of vehicle exhaust and BTW emissions.

Figure 8-39: Changes in $PM_{2.5}$ Emissions Compared to the No-Action Alternative

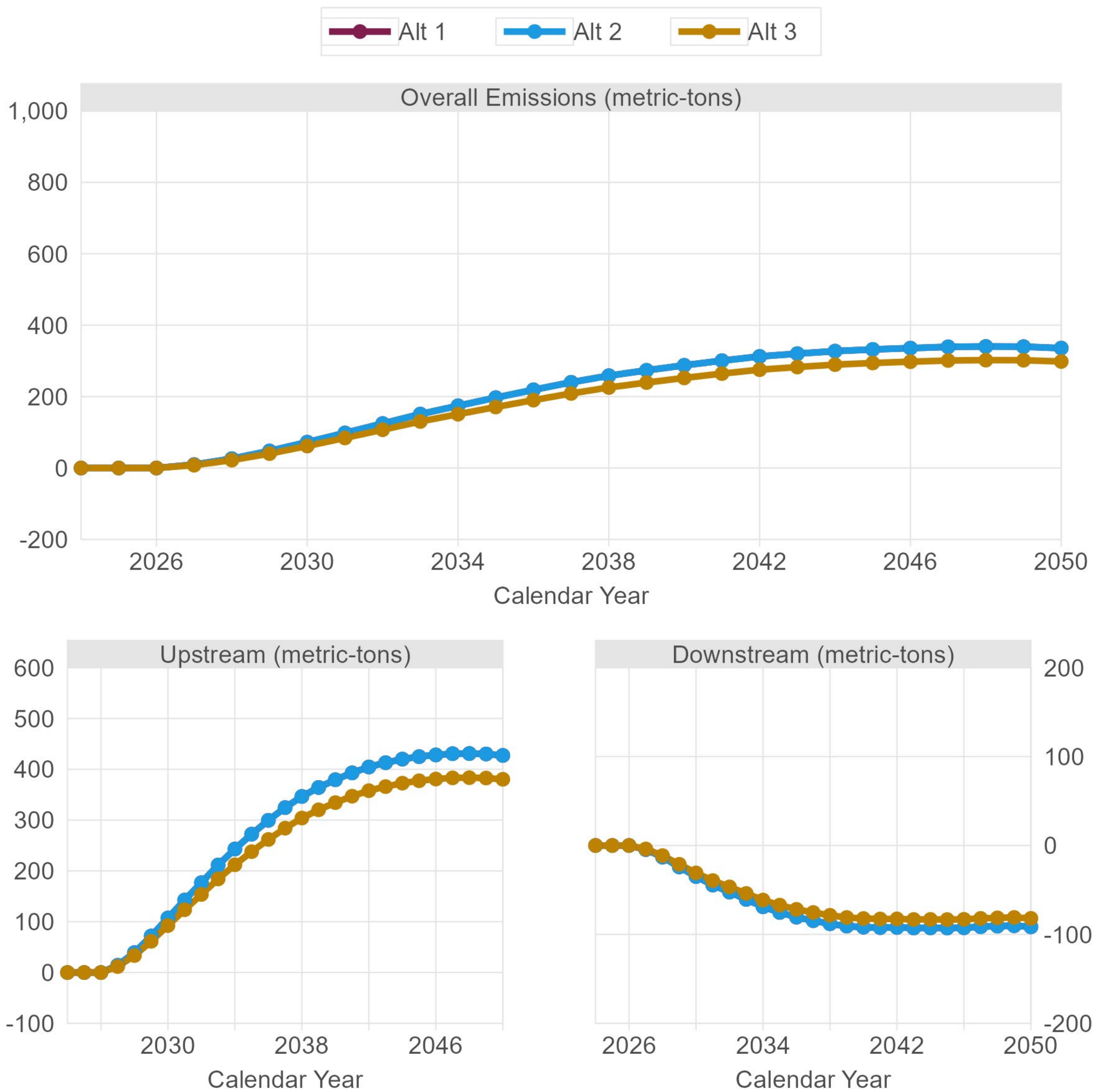
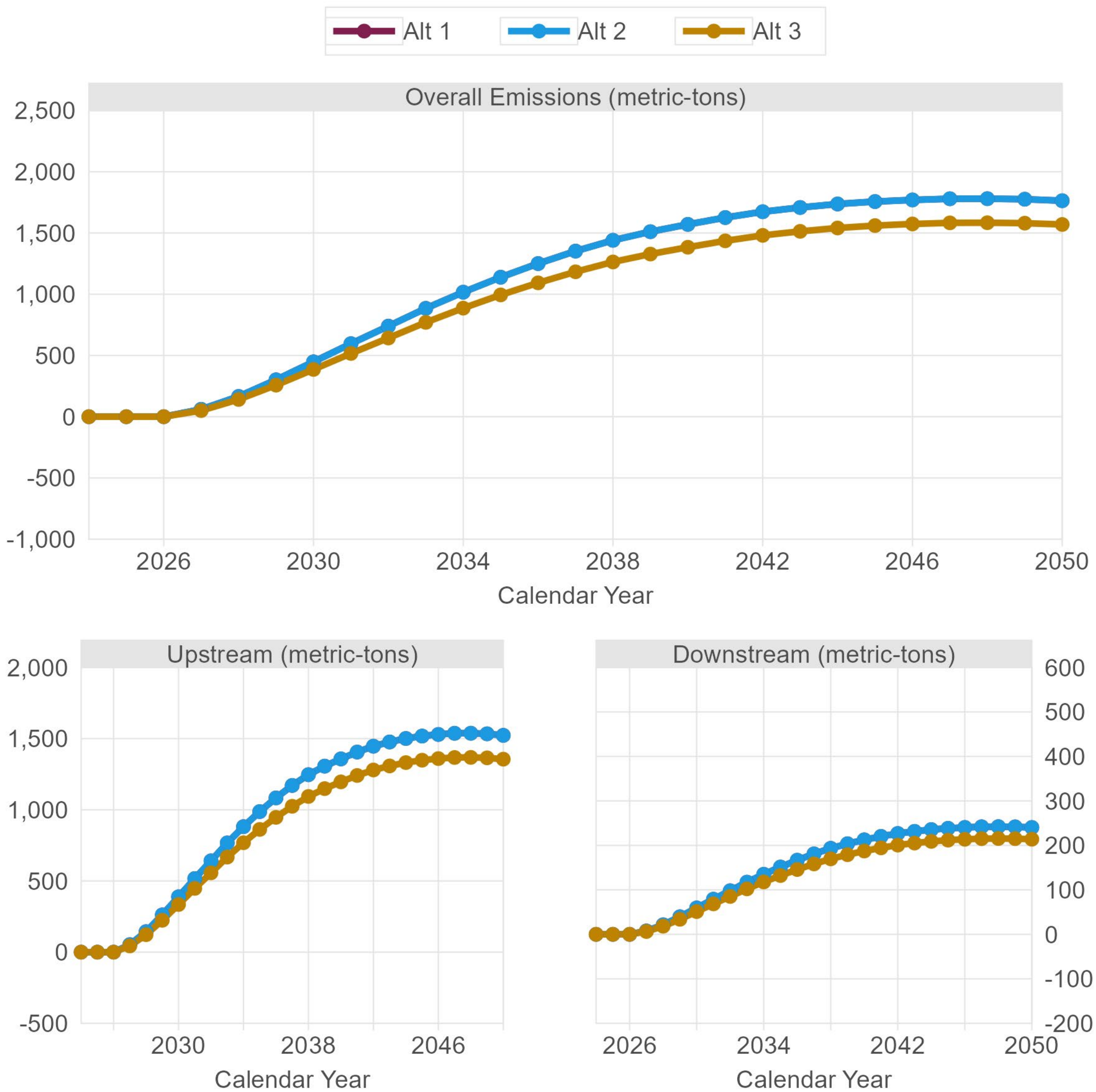


Figure 8-40 illustrates the incremental emission changes for SO_X for the action alternatives relative to the No-Action Alternative. As was noted earlier, the SO_X downstream emissions are measured based on the total consumption of fuel, rather than on a per-mile basis (see Draft TSD Chapter 5.3.3.2). Thus, the increase in fuel use in the action alternatives increases the downstream emissions of SO_X as well as the upstream emissions of SO_X compared to the No-Action Alternative.

Figure 8-40: Changes in SO_X Emissions Compared to Reference Baseline



As demonstrated in this chapter, relative levels of all criteria pollutants increase under each of the action alternatives. The magnitude of the change depends on the pollutant being considered and how its emissions are calculated within the CAFE Model. These results are a direct consequence of the input assumptions used for this analysis and are subject to the usual caveats that accompany uncertainty in input assumptions. When estimating upstream emissions, the CAFE Model relies on the upstream emission rates provided by GREET 2024 for liquid fuels. These input emission rates may change over time (and between rulemaking analyses) depending on the version of the GREET Model used and the associated assumptions about emissions rates and the production and distribution of various petroleum-based feedstocks.

When estimating the downstream emissions, the CAFE Model relies on the emission rates provided by the MOVES5 Model, which defines emissions rates on a per-mile basis (except for the SO_X pollutant), independently for the passenger car and light truck classes. Hence, the differences in the downstream emissions between various alternatives largely depend on the total VMT attributed to the on-road population from each vehicle class. However, some uncertainty also exists regarding the impacts of decreasing standards on new vehicle sales, the mix shifting between cars and trucks, and the longevity of the current on-road vehicle population. As such, the number of miles traveled by the resulting on-road fleet may change in such a way that it may decrease the amount of downstream criteria air pollutants emitted during some calendar years under the less stringent alternatives.

8.5.4. Changes to Adverse Health Outcomes Caused by Exposure to Criteria Pollutants

The magnitude of health outcomes resulting from exposure to criteria air pollutants increases as the consumption of gasoline by the light duty fleet grows between calendar years and with decreased alternative stringencies. Table 8-12 presents the outcomes and proportions for each of the various emission health impacts considered in this rulemaking. Since CY 2024 corresponds to the initial year evaluated for this analysis (MY 2024), and since the CAFE Model does not apply any fuel-saving technologies during that initial year, the health outcomes shown in the table are the same across all alternatives at the beginning of the analysis. For more information about how the agency estimates emission health impacts, see Draft TSD Chapter 5.4.

Table 8-12: Emission Health Outcomes in CY 2024

	Outcomes (Units)	Share of Total Incidents
High Incident Counts		
Minor Restricted Activity Days	2,575,939	78.60%
Work Loss Days	438,910	13.40%
Asthma Exacerbation	101,898	3.10%
Upper Respiratory Symptoms	86,467	2.60%
Lower Respiratory Symptoms	60,905	1.90%
Low Incident Counts		
Acute Bronchitis	4,794	0.15%
Non-Fatal Heart Attacks (Peters)	3,417	0.10%
Premature Deaths	3,303	0.10%
Respiratory Emergency Room Visits	1,840	0.06%
Respiratory Hospital Admissions	868	0.03%
Cardiovascular Hospital Admissions	825	0.03%
Non-Fatal Heart Attacks (All Others)	369	0.01%

Throughout the analysis of all alternatives, the proportion of each category remains mostly the same during each calendar year, and the nominal number of incidences moderately increases with each subsequent year. The emission-related health outcomes attributed to the No-Action Alternative, and all action alternatives, over the analysis period are presented as cumulative impacts from 2024-2050 in Table 8-13.

Table 8-13: Emission Health Outcomes from CYs 2024-2050

Outcomes (Units)	No-Action	Alt 1	Alt 2	Alt 3
High Incident Counts				
Minor Restricted Activity Days	42,168,269	42,517,656	42,517,584	42,475,237
Work Loss Days	7,186,241	7,245,954	7,245,942	7,238,705
Asthma Exacerbation	1,667,489	1,681,435	1,681,432	1,679,742
Respiratory Emergency Room Visits	30,164	30,431	30,431	30,399
Upper Respiratory Symptoms	1,417,530	1,429,426	1,429,423	1,427,982

Lower Respiratory Symptoms	998,788	1,007,223	1,007,221	1,006,200
Low Incident Counts				
Acute Bronchitis	78,541	79,202	79,202	79,122
Non-Fatal Heart Attacks (Peters)	55,888	56,379	56,379	56,320
Premature Deaths	53,814	54,287	54,287	54,230
Cardiovascular Hospital Admissions	14,288	14,415	14,415	14,399
Respiratory Hospital Admissions	13,523	13,644	13,644	13,629
Non-Fatal Heart Attacks (All Others)	6,030	6,083	6,083	6,077

As shown in Table 8-13, health-related outcomes increase as CAFE stringencies decrease because criteria pollutants increase with increase in fuel consumption. The most stringent set of CAFE standards, Alternative 3, sees the lowest increase in the number of health-related outcomes among the alternatives evaluated.

8.6. Summary of Estimated Benefits and Costs by Category

Table 8-14 and Table 8-15 describe the incremental costs and benefits of the proposed reset of CAFE standards for MYs 2027-2031 in each alternative, as well as the party to which they accrue, from the model year and calendar year perspectives, respectively.[149] The choice of the perspective used to measure costs and benefits creates variation in the magnitudes of effects; Chapter 8 contains a discussion of the differences between these two perspectives. The choice of discount rate also affects the resulting estimates of benefits and costs. As the tables show, all alternatives result in total cost savings, but the estimated magnitudes are larger when using the lower discount rates.

Beginning with private costs (the first category of costs in the following tables), vehicle manufacturers are directly regulated under the program and would incur additional production costs when they apply technology to their vehicle offerings to improve their fuel economy (or, conversely, realize cost savings when standards are reduced, as with the regulatory alternatives presented in this proposal). NHTSA assumes that those costs are fully passed through to new car and truck buyers in the form of higher prices, and any cost savings are fully passed on in the form of lower prices. While maintenance and repair cost impacts accrue to buyers of new cars and trucks affected by CAFE standards, such costs are generally less than those for older vehicles. In any event, NHTSA does not include these impacts in the central analysis.

An additional potential private cost of fuel economy standards is the opportunity cost of limiting or precluding improvements in vehicles' features other than their fuel economy. This sacrifice in other vehicle attributes is lessened with each action alternative, representing a cost savings to private buyers. The inclusion of this cost savings accounts for a market distortion caused by CAFE standards.[150] Chapter 4.1.3 of the Draft TSD contains further information regarding the calculation of this implicit opportunity cost.

Regarding private costs, this analysis also assumes that drivers of new vehicles internalize 90 percent of the risk associated with additional crashes. Chapter 7 in the Draft TSD contains additional discussion.

Turning to the external cost categories, most external costs and benefits are driven by changes in either VMT, fuel efficiency and usage, or both. VMT directly impacts congestion costs and noise costs, which are calculated based on per-mile cost estimates. Safety costs not assumed to be internalized (10 percent of costs associated with fatalities and non-fatal injuries plus costs associated with property damages) are treated as external. Emissions costs and fuel tax revenue change based on fuel use per mile and miles driven.

[149] Note that totals in the tables may not sum perfectly due to rounding.
[150] The implicit opportunity cost was included as a sensitivity case in the 2024 final rule, and advancements in research in this area have led to its inclusion in the central analysis of this current rule.

In the case of the three action alternatives, private incremental benefits (fuel cost savings, benefits from additional driving, and refueling frequency) are negative. These benefits are associated with higher fuel economy. These decreased benefits (i.e., increased costs) accrue to new car and truck buyers at retail fuel prices (inclusive of Federal and state taxes). In addition to increased costs of fuel purchases, new vehicle buyers also experience more refueling events and decreased mobility that results from a higher cost of driving their vehicle (lower fuel economy increases the per-mile cost of travel). The decreased mobility is equivalent to the cost savings of forgoing traveling rebound miles and 90 percent of the reduced safety risk from the forgone 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 CAFE standards borne more broadly throughout the economy or society, which the agency refers to as social or external costs.[151] These external cost categories all have similar magnitudes and include congestion and noise, safety costs not internalized by drivers, and the fuel tax revenues that occur from fuel purchases.[152] Because revenue from fuel taxes funds maintenance of roads and bridges as well as other government activities, the change in fuel tax revenue represents a social cost.[153] In the case of the action alternatives, decreases in driving (that occur as new-vehicle buyers experience higher per-mile fuel costs) act as a cost to those drivers, but the decrease in congestion (and road noise) created by the lack of additional travel also serves as a social benefit to all road users. Similarly, while aggregate VMT declines, fuel consumption increases, leading to a gain in fuel tax revenue.

Finally, the purely external benefits created when CAFE standards change include beneficial health outcomes from reduced exposure to criteria pollutants and improved energy security. In this NPRM, both benefit values decrease relative to the baseline in all regulatory alternatives.

Table 8-14: Incremental Benefits and Costs over the Lifetimes of the Total Fleet Produced Through MY 2031 (2024$ Billions), by Alternative

	3% Discount Rate			7% Discount Rate		
	Alt 1	Alt 2	Alt 3	Alt 1	Alt 2	Alt 3
Private Costs						
Technology Costs	-37.1	-37.1	-33.7	-30.3	-30.3	-27.5
Maintenance and Repair Costs*	-	-	-	-	-	-
Sacrifice in Other Vehicle Attributes	-26.6	-26.5	-23.0	-16.9	-16.9	-14.6
Consumer Surplus Loss	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0
Safety Costs Internalized by Drivers	-22.9	-22.9	-20.5	-14.4	-14.4	-12.9
Subtotal - Private Costs	-86.5	-86.4	-77.2	-61.6	-61.5	-55.0
External Costs						
Congestion and Noise Costs From Rebound-Effect Driving	-9.6	-9.6	-8.5	-6.1	-6.1	-5.4
Safety Costs Not Internalized by Drivers	-4.1	-4.1	-3.7	-2.6	-2.6	-2.3
Loss in Fuel Tax Revenue	-9.0	-9.0	-7.8	-5.8	-5.8	-5.0
Subtotal - External Costs	-22.7	-22.7	-20.0	-14.5	-14.5	-12.7
Total Costs (incl. private)	-109.2	-109.1	-97.1	-76.1	-76.0	-67.7

[151] Some external benefits and 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.
[152] Changes in tax revenues are a transfer and not an economic externality as traditionally defined, but these are grouped 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.
[153] Fuel tax revenue may subsequently be replaced by another source of revenue, but that is beyond the scope of this rulemaking to examine.

Private Benefits						
Fuel Cost Savings	-53.9	-53.9	-46.5	-34.2	-34.2	-29.5
Benefits From Additional Driving	-25.1	-25.1	-21.7	-15.8	-15.8	-13.7
Refueling Frequency	-3.0	-3.0	-2.7	-1.9	-1.9	-1.7
Subtotal - Private Benefits	-82.1	-82.0	-70.8	-52.0	-51.9	-44.9
External Benefits						
Petroleum Market Security	-2.2	-2.2	-1.9	-1.4	-1.4	-1.2
Health Outcomes	-0.8	-0.8	-0.7	-0.5	-0.5	-0.4
Total Benefits (incl. private)	-85.2	-85.1	-73.5	-53.9	-53.8	-46.5
Total Net Benefits	24.0	24.0	23.7	22.2	22.2	21.2
* The costs of maintenance and repair are not estimated.						

Table 8-15: Incremental Benefits and Costs for the On-Road Fleet CYs 2024-2050 (2024$ Billions), by Alternative

	3% Discount Rate			**7% Discount Rate**		
	Alt 1	**Alt 2**	**Alt 3**	**Alt 1**	**Alt 2**	**Alt 3**
Private Costs						
Technology Costs	-150.1	-150.0	-138.0	-94.0	-94.0	-86.3
Maintenance and Repair Costs*	-	-	-	-	-	-
Sacrifice in Other Vehicle Attributes	-119.2	-119.2	-105.2	-57.4	-57.4	-50.5
Consumer Surplus Loss	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
Safety Costs Internalized by Drivers	-57.3	-57.3	-51.1	-31.3	-31.3	-27.9
Subtotal - Private Costs	-326.5	-326.4	-294.1	-182.6	-182.6	-164.6
External Costs						
Congestion and Noise Costs From Rebound-Effect Driving	-26.6	-26.6	-23.6	-14.6	-14.6	-12.9
Safety Costs Not Internalized by Drivers	-11.0	-11.0	-9.8	-6.0	-6.0	-5.4
Loss in Fuel Tax Revenue	-29.8	-29.8	-26.2	-16.3	-16.3	-14.3
Subtotal - External Costs	-67.4	-67.4	-59.7	-37.0	-36.9	-32.6
Total Costs (incl. private)	-393.9	-393.8	-353.8	-219.6	-219.5	-197.2
Private Benefits						
Fuel Cost Savings	-185.4	-185.4	-163.3	-100.6	-100.6	-88.4
Benefits From Additional Driving	-84.3	-84.3	-74.1	-45.4	-45.4	-39.8
Refueling Frequency	-10.1	-10.1	-9.0	-5.5	-5.5	-4.9

Subtotal - Private Benefits	-279.8	-279.7	-246.5	-151.5	-151.4	-133.2
External Benefits						
Petroleum Market Security	-7.8	-7.8	-6.9	-4.2	-4.2	-3.7
Health Outcomes	-3.5	-3.5	-3.1	-1.7	-1.7	-1.5
Total Benefits (incl. private)	-291.2	-291.1	-256.5	-157.4	-157.4	-138.4
Total Net Benefits	102.8	102.8	97.3	62.1	62.1	58.8

* The costs of maintenance and repair are not estimated.

9. Expanded Sensitivity Analysis

9.1. Description of Sensitivity Cases

The results presented in Chapter 8 are based on NHTSA's proposed rule. That analysis relies on many different inputs, assumptions that reflect the agency's best judgments regarding the anticipated outcomes of the proposed CAFE standards recognizes that there may be uncertainty in certain respects and analytical assumptions, and that this produces uncertainty benefits, costs, and other outcomes. As it has done in past conducted additional CAFE Model runs with alternative inputs, yielding information about the sensitivity of the Model to cases presented in this chapter cover assumptions related to cost, economic conditions, consumer preferences, and others.

CAFE Model Files Referenced in this Chapter.

Below is a list of CAFE Model Files referenced in this chapter. See Draft TSD Chapter 2.1.9 "Where to Find the Internal NHTSA Files" for a full list of files referenced in this document and their respective file locations.

- Market Data Input File

"central" analysis of the parameters and other analytical a variety of factors relevant to reset. However, NHTSA about certain of the input values for some estimates of the CAFE rulemakings, NHTSA also assumptions about a range of those inputs. The sensitivity technology applicability and externality values, among

In contrast to an uncertainty analysis, where many assumptions are varied simultaneously, the sensitivity analyses included here typically vary a single assumption and thus provide information about the influence of each individual factor on the results, rather than suggesting that an alternative set of assumptions would have justified a different Preferred Alternative.[154] NHTSA's CAFE analysis contains hundreds of assumptions and most of them are uncertain—particularly those applying several years in the future. A sensitivity analysis can identify two critical pieces of information: *how big an influence* does each parameter exert on the analysis, and *how sensitive are the model results* to that assumption?

For example, if oil prices are lower than the projections used in the central analysis, future technology adoption choices and incremental technology costs will produce smaller differences in the real world relative to the estimates presented in this rulemaking analysis. Many different metrics are affected by the assumptions in this analysis—market adoption of fuel economy-improving technologies in the central analysis, new vehicle prices, sales of new vehicles and scrappage of used vehicles, and VMT. The sensitivity analysis for oil prices thus demonstrates that the analytical assumptions about oil prices can have significant effects on several relevant metrics and alternative assumptions can dramatically raise or lower the magnitude of estimated net benefits and consumer costs associated with the regulatory alternatives.

NHTSA does not mean to suggest, however, that any of the sensitivity cases presented here are more likely than the assumptions applied in the central analysis. The sensitivity analysis simply provides an indication of which assumptions are most impactful, and the extent to which future deviations from the central analysis assumptions could affect the actual future costs and future benefits of this rule. For a full discussion of how this information relates to NHTSA's determination of the proposed alternative that represents the maximum feasible standard, considering technological feasibility, economic practicality, the effect of other motor vehicle standards of the Government on fuel economy, and the need of the United States to conserve energy, please see preamble Section V.

[154] The Preferred Alternative is defined in PRIA Chapter. 3 and preamble Section III.

NHTSA summarizes the results of the sensitivity analysis below, and detailed model inputs and outputs are available on the agency's website.[155] These are reported as incremental values for the Preferred Alternative relative to the No-Action Alternative for each sensitivity case. NHTSA compares these results with the incremental effects for the Preferred Alternative relative to the No-Action Alternative in the central analysis. It is important to note that results under both the No-Action Alternative and the Preferred Alternative (i.e., the proposed CAFE standards) change for each sensitivity case; the *incremental* changes are not only due to a change in the projected outcomes of the regulatory alternative, but also to changes in the projected outcomes in the No-Action Alternative. To the extent that the alternative assumptions alter the amount or pace of technology adoption within the No-Action Alternative and Preferred Alternative, this has implications for the estimates of net benefits associated with the Preferred Alternative.

Table 9-1 lists and describes the alternative cases included in the sensitivity analysis presented in this chapter. All sensitivity cases are variants of the central analysis, including the application of statutory restrictions (e.g., treatment of dedicated alternative fueled vehicles).

Table 9-1: Cases and Baselines Included in the Sensitivity Analysis

Case Name	Description
Central analysis	The analysis that NHTSA uses to estimate the impacts of this proposed rulemaking. This is the analysis to which each sensitivity case is compared.
Annual vehicle redesigns	Vehicles redesigned every model year
No advanced engines	Skips advanced engine technologies including start/stop 12V and 48V systems
Oil price (high)	Fuel prices from AEO 2025 High Oil Price Case
Oil price (low)	Fuel prices from AEO 2025 Low Oil Price Case
Gross Domestic Product (GDP) (high)	GDP and sales based on spring Global Insights optimistic economic growth case
GDP (low)	GDP and sales based on spring Global Insights pessimistic 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

[155] NHTSA, CAFE Compliance and Effects Modeling System: The Volpe Model, Last revised: 2024, available at: https://www.nhtsa.gov/corporate-average-fuel-economy/cafe-compliance-and-effects-modeling-system (accessed: Sept. 10, 2025).

24-month payback period	Payback period set to 24 months
30-month payback period	Payback period set to 30 months
60-month payback period	Payback period set to 60 months
Rebound (10%)	Rebound effect set at 10 percent
Rebound (20%)	Rebound effect set at 20 percent
Sales-scrappage response (-0.1)	Sales-scrappage model with price elasticity multiplier of -0.1
Sales-scrappage response (-1)	Sales-scrappage model with price elasticity multiplier of -1
Light-duty vehicle sales (AEO Ref. 2025 growth)	Light-duty vehicles sales rate of change and gas-powered share in 2025-50 consistent with AEO 2025 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 2024 value
Fixed fleet share, no price response	Fixed fleet share at 2024 level, fleet share elasticity set to zero
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
Apply CO_2 value[156]	2019 EPA domestic only CO_2 monetization value

[156] NHTSA's sensitivity cases applying a monetized value to changes in NCEs use NCE values derived from the 2019 EPA Regulatory Impact Analysis for the Repeal of the Clean Power Plan. EPA, Regulatory Impact Analysis for the Repeal of the Clean Power Plan, and the Emission Guidelines for Greenhouse Gas Emissions From Existing Electric Utility Generating Units, EPA-452/R-19-003 EPA: Washington, DC (2019), available at: https://www.epa.gov/sites/default/files/2019-06/documents/utilities_ria_final_cpp_repeal_and_ace_2019-06.pdf (accessed: Sept. 10, 2025). These values (per metric ton) range from $8.98 (2024) to $13.98 (2050) for CO2, $268.58 to $474.37 for CH4, and $3144.65 to $5033.59 for N20 (3% discount rate, 2024 dollars). The specific values used for this sensitivity at both 3-percent and 7-percent discount rates can be found in the Parameters Input file associated with these sensitivity cases.

Apply CO_2, CH_4, N_2O values	2019 EPA domestic only CO_2, CH_4, and N_2O monetization values
Advanced Manufacturing Production Credit (AMPC) 26-31	AMPC included in MYs 2026-2031
No vehicle reclassification	Remove reclassification in the action alternatives
Reclassified vehicles in the No-Action Alternative	Include reclassification in the No-Action Alternative
AC/OC phase-out in 2032	Maintain central analysis AC/OC levels through action alternatives
No AC/OC in No-Action Alternative	AC/OC phased out in MY 2028 in all alternatives including No-Action Alternative
Proposed standards (2022-2026)	Replace existing MYs 2022-2026 standards with Alternative 2's (Preferred Alternative) standards

9.2. Summary of Sensitivity Results

9.2.1. Effect of Assumptions on Primary Cost and Benefit Measures

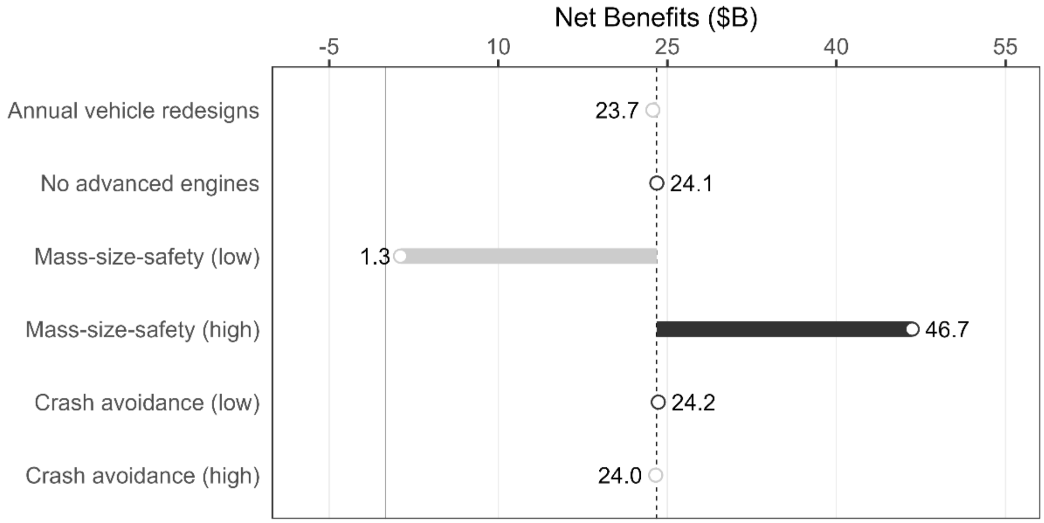
This chapter includes figures and tables that summarize the change in net benefits, technology application, and other metrics in each sensitivity case for the proposed alternative relative to the central analysis.[157] Total costs and benefits are computed on a model year basis for the full light duty fleet (MYs 1985-2031).[158]

Figure 9-1 through Figure 9-4 illustrate the effect of varying an array of model input assumptions. The axis measuring net benefits is fixed across the figures to ease comparison. Table 9-2 presents the total costs, total benefits, and net benefits associated with the three regulatory alternatives for vehicles in MYs 1985-2031 under 3-percent discounting. Table 9-3 presents the same metrics using 7-percent discounting. Table 9-4 and Table 9-5 summarize key output measures, including fuel consumption and associated emissions, consumer costs and benefits, total vehicle sales, and effects on jobs under 3- and 7-percent discounting.

[157] The differences in net benefits could be greater or smaller for other action alternatives or discount rate assumptions, depending on the specific input being adjusted. Complete model outputs for these sensitivity cases are included in the online documentation, available at: https://www.nhtsa.gov/corporate-average-fuel-economy/cafe-compliance-and-effects-modeling-system.
[158] Chapter 5.3 outlines the differences between *model year* analysis and *calendar year* analysis for the purposes of this proposed rule and discusses the use of the two methods in presenting results for the CAFE fuel economy standards.

Table 9-6 shows technology penetration rates for some ICE and hybridization technologies for the Preferred Alternative broken out by sensitivity.[159] More detailed discussions of selected sensitivity cases are included in the remaining portions of this chapter.

Figure 9-1: Net Social Benefits Over the Lifetime of Vehicles Through MY 2031 (MYs 1985-2031) for the Preferred Alternative (Alt. 2), Technology and Safety Assumptions Sensitivity Cases (2024$, 3% Discount Rate)



Dashed line indicates central analysis net benefits ($24.0 B).

[159] Note that sensitivity case results presented in Table 9-6
Table 9-6 may reflect changes in technology penetration rates (as simulated in the CAFE Model) under both the Preferred Alternative and the No-Action Alternative, which are not identical across scenarios because the assumptions in the sensitivity case affect behavior both in the No-Action Alternative and action alternatives, so comparing sensitivity cases must account for the adjustments in No-Action Alternative *and* the changes produced by the Preferred Alternative.

Figure 9-2: Net Social Benefits Over the Lifetime of Vehicles Through MY 2031 (MYs 1985-2031) for the Preferred Alternative (Alt. 2), Macroeconomic Assumptions Sensitivity Cases (2024$, 3% Discount Rate)

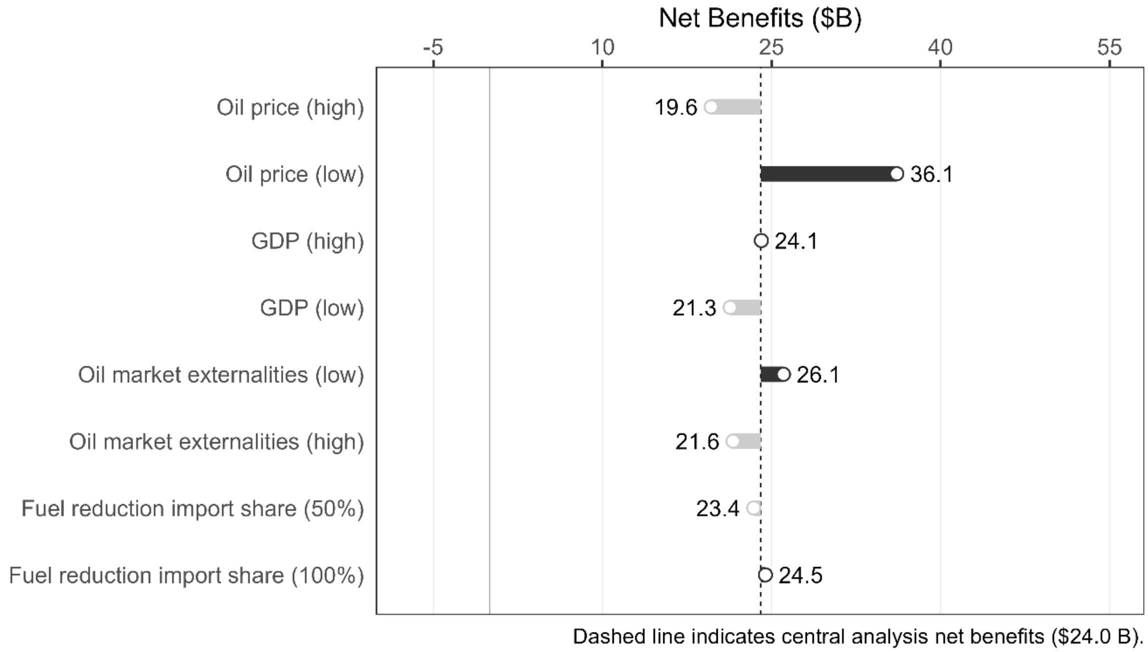


Figure 9-3: Net Social Benefits Over the Lifetime of Vehicles Through MY 2031 (MYs 1985-2031) for the Preferred Alternative (Alt. 2), Payback, VMT, and Fleet Turnover Assumptions Sensitivity Cases (2024$, 3% Discount Rate)

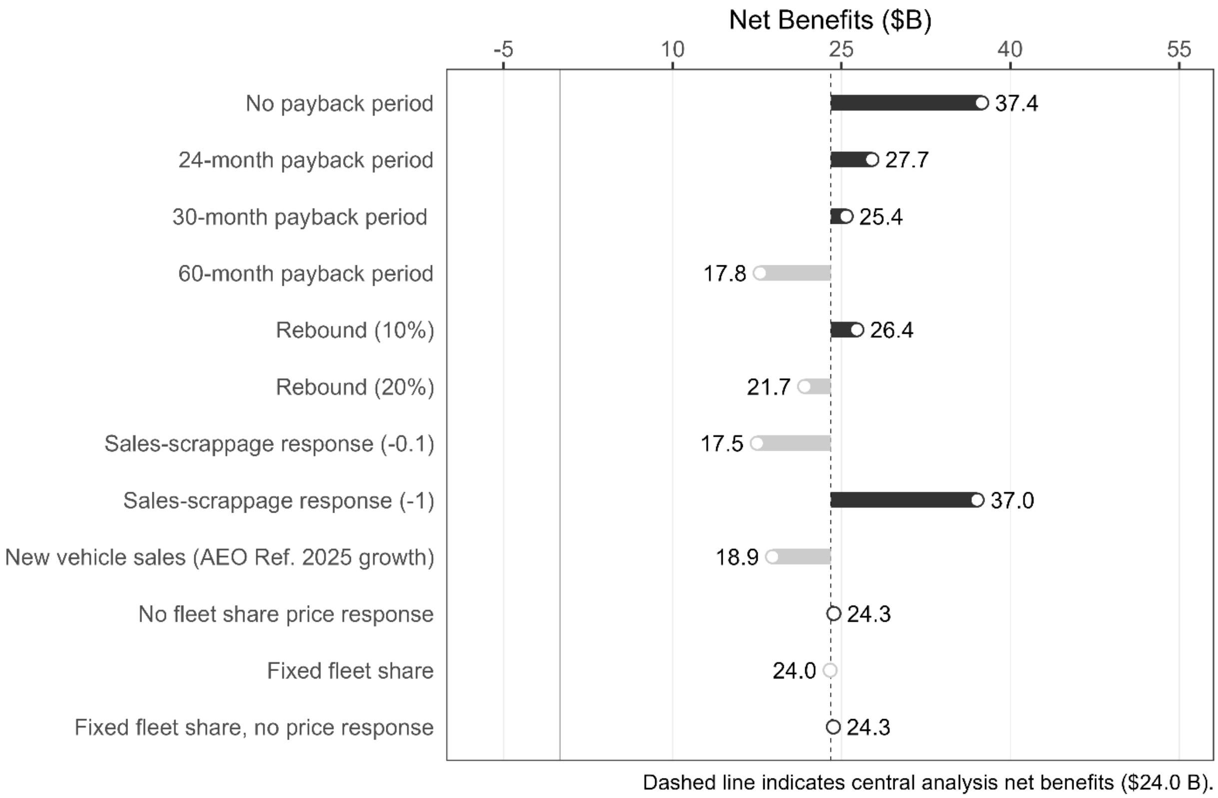
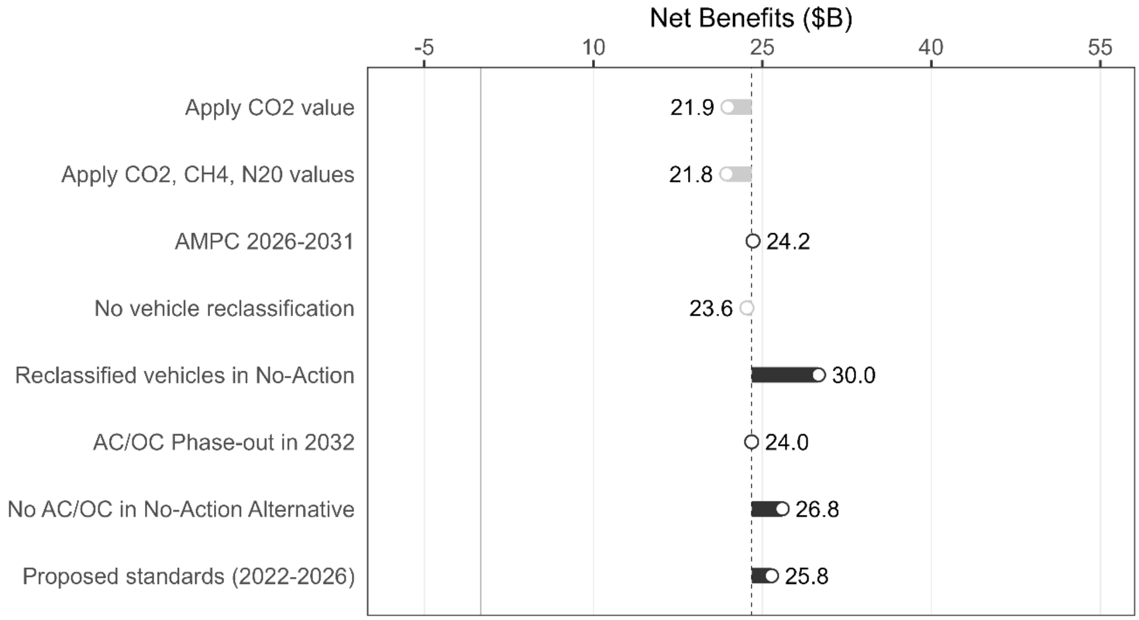


Figure 9-4: Net Social Benefits Over the Lifetime of Vehicles Through MY 2031 (MYs 1985-2031) for the Preferred Alternative (Alt. 2), Policy and Other Assumptions Sensitivity Cases (2024$, 3% Discount Rate)



Dashed line indicates central analysis net benefits ($24.0 B).

Table 9-2: Aggregate Costs and Benefits Over the Lifetime of Vehicles Through MY 2031 (MYs 1985-2031) for the Regulatory Alternatives, by Sensitivity Case (2024$, 3% Discount Rate)

Sensitivity Case	Costs			Benefits			Net Benefits		
	Alt. 1	Alt. 2	Alt. 3	Alt. 1	Alt. 2	Alt. 3	Alt. 1	Alt. 2	Alt. 3
Central analysis	-109.2	-109.1	-97.1	-85.2	-85.1	-73.5	24.0	24.0	23.7
Annual vehicle redesigns	-53.4	-53.4	-52.0	-29.6	-29.6	-28.2	23.7	23.7	23.8
No advanced engines	-109.0	-108.9	-97.1	-85.0	-84.8	-73.4	24.1	24.1	23.7
Oil price (high)	-108.8	-108.7	-99.3	-89.1	-89.0	-79.9	19.6	19.6	19.4
Oil price (low)	-108.2	-107.0	-92.7	-72.0	-70.9	-58.4	36.2	36.1	34.3
GDP (high)	-107.3	-107.2	-95.5	-83.2	-83.1	-71.8	24.1	24.1	23.7
GDP (low)	-95.3	-95.2	-84.9	-74.0	-73.9	-63.8	21.3	21.3	21.0
Oil market externalities (low)	-109.2	-109.1	-97.1	-83.2	-83.1	-71.7	26.1	26.1	25.4
Oil market externalities (high)	-109.2	-109.1	-97.1	-87.6	-87.5	-75.6	21.6	21.6	21.6
Fuel reduction import share (50%)	-109.2	-109.1	-97.1	-85.8	-85.7	-74.0	23.4	23.4	23.1
Fuel reduction import share (100%)	-109.2	-109.1	-97.1	-84.8	-84.7	-73.1	24.5	24.5	24.0
No payback period	-182.9	-176.2	-141.4	-145.7	-138.7	-105.6	37.2	37.4	35.9
24-month payback period	-132.2	-130.1	-112.0	-104.6	-102.4	-84.7	27.6	27.7	27.3
30-month payback period	-121.4	-121.1	-104.2	-96.0	-95.7	-78.9	25.4	25.4	25.4
60-month payback period	-76.0	-76.0	-72.2	-58.2	-58.2	-54.6	17.8	17.8	17.6

Rebound (10%)	-118.4	-118.3	-105.2	-92.1	-92.0	-79.5	26.4	26.4	25.7
Rebound (20%)	-100.0	-99.9	-89.1	-78.3	-78.2	-67.4	21.7	21.7	21.7
Sales-scrappage response (-0.1)	-104.5	-104.4	-92.6	-87.0	-86.9	-75.2	17.5	17.5	17.4
Sales-scrappage response (-1)	-118.6	-118.6	-106.4	-81.6	-81.5	-70.3	37.0	37.0	36.2
AEO 2025 sales	-83.9	-83.8	-74.5	-65.0	-64.9	-56.0	18.9	18.9	18.6
No fleet share price response	-109.2	-109.1	-97.1	-84.9	-84.8	-73.3	24.3	24.3	23.9
Fixed fleet share	-109.0	-108.9	-97.2	-85.0	-84.9	-73.5	24.0	24.0	23.7
Fixed fleet share, no price response	-108.9	-108.9	-97.2	-84.7	-84.6	-73.3	24.3	24.3	23.8
Mass-size-safety (low)	-85.3	-85.2	-76.8	-84.0	-83.9	-72.4	1.3	1.3	4.4
Mass-size-safety (high)	-133.1	-133.0	-117.5	-86.3	-86.3	-74.6	46.7	46.7	42.9
Crash avoidance (low)	-110.7	-110.6	-98.4	-86.5	-86.4	-74.6	24.2	24.2	23.8
Crash avoidance (high)	-108.3	-108.2	-96.3	-84.3	-84.2	-72.7	24.0	24.0	23.6
2019 EPA Domestic Only CO_2	-109.2	-109.1	-97.1	-87.3	-87.2	-75.3	21.9	21.9	21.9
2019 EPA Domestic Only CO_2, CH_4, N_2O	-109.2	-109.1	-97.1	-87.4	-87.3	-75.4	21.8	21.8	21.8
AMPC 2026-2031	-109.3	-109.2	-97.2	-85.1	-85.0	-73.4	24.2	24.2	23.8
No reclassification	-108.1	-107.3	-107.0	-84.2	-83.6	-83.4	23.9	23.6	23.6
Reclassified baseline	-128.4	-128.3	-116.3	-98.4	-98.3	-86.7	30.0	30.0	29.6
AC-OC phase-out in 2032	-109.3	-109.3	-104.7	-85.2	-85.2	-80.7	24.0	24.0	24.0
No AC-OC in No-Action Alternative	-120.4	-120.3	-108.3	-93.7	-93.6	-81.9	26.8	26.8	26.4
Proposed standards (2022-2026)	-115.9	-115.0	-102.4	-90.1	-89.2	-77.0	25.8	25.8	25.4

Table 9-3: Aggregate Costs and Benefits Over the Lifetime of Vehicles Through MY 2031 (MYs 1985-2031) for the Regulatory Alternatives, by Sensitivity Case (2024$, 7% Discount Rate)

Sensitivity Case	Costs			Benefits			Net Benefits		
	Alt. 1	Alt. 2	Alt. 3	Alt. 1	Alt. 2	Alt. 3	Alt. 1	Alt. 2	Alt. 3
Central analysis	-76.1	-76.0	-67.7	-53.9	-53.8	-46.5	22.2	22.2	21.2
Annual vehicle redesigns	-36.7	-36.7	-35.9	-18.5	-18.5	-17.6	18.3	18.3	18.2
No advanced engines	-75.9	-75.8	-67.7	-53.8	-53.7	-46.5	22.1	22.1	21.2
Oil price (high)	-75.4	-75.4	-68.9	-56.9	-56.8	-51.0	18.6	18.6	17.9
Oil price (low)	-76.0	-75.1	-65.2	-46.2	-45.4	-37.4	29.8	29.7	27.8
GDP (high)	-74.7	-74.7	-66.6	-52.7	-52.7	-45.5	22.0	22.0	21.1
GDP (low)	-66.1	-66.1	-58.9	-46.6	-46.6	-40.2	19.5	19.5	18.7
Oil market externalities (low)	-76.1	-76.0	-67.7	-52.6	-52.6	-45.4	23.4	23.4	22.3
Oil market externalities (high)	-76.1	-76.0	-67.7	-55.4	-55.4	-47.8	20.6	20.6	19.9

Fuel reduction import share (50%)	-76.1	-76.0	-67.7	-54.3	-54.2	-46.8	21.8	21.8	20.9
Fuel reduction import share (100%)	-76.1	-76.0	-67.7	-53.7	-53.6	-46.3	22.4	22.4	21.4
No payback period	-129.4	-124.7	-100.3	-92.1	-87.7	-66.8	37.3	37.0	33.6
24-month payback period	-92.5	-91.0	-78.4	-66.2	-64.8	-53.6	26.3	26.2	24.9
30-month payback period	-84.8	-84.5	-72.9	-60.8	-60.6	-49.9	24.0	24.0	22.9
60-month payback period	-52.5	-52.5	-49.9	-36.8	-36.8	-34.5	15.7	15.7	15.4
Rebound (10%)	-81.9	-81.8	-72.8	-58.2	-58.2	-50.3	23.7	23.7	22.5
Rebound (20%)	-70.2	-70.2	-62.6	-49.6	-49.5	-42.7	20.6	20.6	19.9
Sales-scrappage response (-0.1)	-73.2	-73.2	-65.0	-54.9	-54.9	-47.5	18.3	18.3	17.5
Sales-scrappage response (-1)	-81.7	-81.6	-73.3	-51.8	-51.8	-44.7	29.9	29.9	28.6
AEO 2025 sales	-58.7	-58.6	-52.2	-41.4	-41.4	-35.7	17.3	17.3	16.5
No fleet share price response	-76.0	-76.0	-67.7	-53.7	-53.7	-46.4	22.3	22.3	21.3
Fixed fleet share	-75.9	-75.8	-67.7	-53.8	-53.7	-46.5	22.1	22.1	21.2
Fixed fleet share, no price response	-75.8	-75.8	-67.7	-53.6	-53.5	-46.4	22.3	22.2	21.3
Mass-size-safety (low)	-61.2	-61.1	-55.1	-53.2	-53.1	-45.8	8.0	8.0	9.3
Mass-size-safety (high)	-90.9	-90.8	-80.3	-54.6	-54.6	-47.2	36.2	36.2	33.1
Crash avoidance (low)	-76.9	-76.9	-68.5	-54.7	-54.7	-47.2	22.2	22.2	21.3
Crash avoidance (high)	-75.5	-75.4	-67.2	-53.4	-53.3	-46.0	22.1	22.1	21.2
2019 EPA Domestic Only CO_2	-76.1	-76.0	-67.7	-56.0	-55.9	-48.3	20.0	20.0	19.4
2019 EPA Domestic Only CO_2, CH_4, N_2O	-76.1	-76.0	-67.7	-56.1	-56.1	-48.4	19.9	19.9	19.3
AMPC 2026-2031	-76.1	-76.0	-67.8	-53.9	-53.8	-46.5	22.2	22.2	21.3
No vehicle reclassification	-75.3	-74.7	-74.5	-53.3	-52.9	-52.8	22.0	21.8	21.7
Reclassified vehicles in No-Action Alternative	-89.4	-89.4	-81.1	-62.3	-62.3	-54.9	27.1	27.1	26.2
AC/OC phase-out in 2032	-76.1	-76.1	-73.0	-53.9	-53.9	-51.1	22.2	22.2	21.9
No AC-OC in No-Action Alternative	-83.8	-83.8	-75.5	-59.3	-59.2	-51.9	24.6	24.6	23.7
Proposed standards (2022-2026)	-80.8	-80.1	-71.4	-57.1	-56.5	-48.8	23.7	23.6	22.6

Table 9-4: Selected Model Metrics for the Preferred Alternative (Alt. 2), by Sensitivity Case (2024$, 3% Discount Rate)[160]

Sensitivity case	Gasoline consumption (b.gal)	Fatalities	CO_2 Emissions (MMT)	Criteria Emissions Deaths	MY 2031 Regulatory cost ($/vehicle)	MY 2031 Retail fuel expenditure ($/vehicle)	MY 2031 Sales	MY 2031 Jobs
Central analysis	96	-1,567	1,052	473	-925	1,431	47,133	-7,185
Annual vehicle redesigns	57	-926	628	277	-724	811	45,703	-5,141
No advanced engines	96	-1,566	1,049	471	-916	1,402	46,947	-7,066
Oil price (high)	78	-1,657	858	363	-846	1,430	36,610	-6,865
Oil price (low)	121	-1,191	1,331	651	-983	1,182	58,773	-7,162
GDP (high)	98	-1,591	1,069	481	-928	1,429	46,624	-7,171
GDP (low)	87	-1,428	958	430	-925	1,445	42,336	-6,430
Oil market externalities (low)	96	-1,567	1,052	473	-925	1,431	47,133	-7,185
Oil market externalities (high)	96	-1,567	1,052	473	-925	1,431	47,133	-7,185
Fuel reduction import share (50%)	96	-1,567	1,052	774	-925	1,431	47,133	-7,185
Fuel reduction import share (100%)	96	-1,567	1,052	272	-925	1,431	47,133	-7,185
No payback period	157	-2,468	1,717	788	-1,052	2,224	37,479	-9,556
24-month payback period	117	-1,854	1,282	581	-992	1,701	46,045	-8,227
30-month payback period	109	-1,714	1,194	539	-968	1,585	46,849	-7,812
60-month payback period	61	-1,076	664	293	-777	1,004	44,962	-5,708
Rebound (10%)	94	-2,077	1,025	420	-925	1,397	47,133	-7,185
Rebound (20%)	98	-1,058	1,079	526	-925	1,464	47,133	-7,185
Sales-scrappage response (-0.1)	96	-1,530	1,054	485	-925	1,461	11,751	-9,540
Sales-scrappage response (-1)	96	-1,641	1,047	449	-925	1,370	117,888	-2,475
AEO 2025 sales	62	-1,031	683	302	-927	1,439	30,895	-4,733

[160] Values shown are cumulative totals for CYs 2024-2050 unless otherwise noted.

No fleet share price response	96	-1,567	1,049	472	-925	1,426	47,245	-7,432
Fixed fleet share	95	-1,597	1,044	469	-921	1,421	47,099	-7,334
Fixed fleet share, no price response	96	-1,567	1,049	472	-925	1,426	47,245	-7,432
Mass-size-safety (low)	96	272	1,052	473	-925	1,431	47,133	-7,185
Mass-size-safety (high)	96	-3,402	1,052	473	-925	1,431	47,133	-7,185
Crash avoidance (low)	96	-1,642	1,052	473	-925	1,431	47,133	-7,185
Crash avoidance (high)	96	-1,452	1,052	473	-925	1,431	47,133	-7,185
2019 EPA Domestic Only CO_2	96	-1,567	1,052	473	-925	1,431	47,133	-7,185
2019 EPA Domestic Only CO_2, CH_4, N_2O	96	-1,567	1,052	473	-925	1,431	47,133	-7,185
AMPC 2026-2031	96	-1,567	1,052	473	-925	1,431	46,609	-7,242
No vehicle reclassification	94	-1,529	1,027	461	-910	1,404	46,470	-7,033
Reclassified vehicles in No-Action Alternative	114	-1,842	1,245	559	-1,116	1,677	58,040	-8,147
AC/OC phase-out in 2032	96	-1,568	1,052	473	-925	1,431	47,123	-7,185
No AC-OC in No-Action Alternative	107	-1,729	1,170	526	-1,038	1,597	53,051	-8,149
Proposed standards (2022-2026)	101	-1,654	1,105	496	-972	1,495	49,729	-7,503

Table 9-5: Selected Model Metrics for the Preferred Alternative (Alt. 2), by Sensitivity Case (2024$, 7% Discount Rate)[161]

Sensitivity case	Gasoline consumption (b.gal)	Fatalities	CO_2 Emissions (MMT)	Criteria Emissions Deaths	Regulatory cost ($/vehicle)	Retail fuel expenditure ($/vehicle)	MY 2031 Sales	MY 2031 Jobs
Central analysis	96	-1,567	1,052	473	-925	1,112	47,133	-7,185
Annual vehicle redesigns	57	-926	628	277	-724	631	45,703	-5,141
No advanced engines	96	-1,566	1,049	471	-916	1,090	46,947	-7,066

[161] Values shown are totals for CYs 2024-2050 unless otherwise noted.

Oil price (high)	78	-1,657	858	363	-846	1,119	36,610	-6,865
Oil price (low)	121	-1,191	1,331	651	-983	930	58,773	-7,162
GDP (high)	98	-1,591	1,069	481	-928	1,113	46,624	-7,171
GDP (low)	87	-1,428	958	430	-925	1,120	42,336	-6,430
Oil market externalities (low)	96	-1,567	1,052	473	-925	1,112	47,133	-7,185
Oil market externalities (high)	96	-1,567	1,052	473	-925	1,112	47,133	-7,185
Fuel reduction import share (50%)	96	-1,567	1,052	774	-925	1,112	47,133	-7,185
Fuel reduction import share (100%)	96	-1,567	1,052	272	-925	1,112	47,133	-7,185
No payback period	157	-2,468	1,717	788	-1,052	1,723	37,479	-9,556
24-month payback period	117	-1,854	1,282	581	-992	1,321	46,045	-8,227
30-month payback period	109	-1,714	1,194	539	-968	1,232	46,849	-7,812
60-month payback period	61	-1,076	664	293	-777	782	44,962	-5,708
Rebound (10%)	94	-2,077	1,025	420	-925	1,085	47,133	-7,185
Rebound (20%)	98	-1,058	1,079	526	-925	1,139	47,133	-7,185
Sales-scrappage response (-0.1)	96	-1,530	1,054	485	-925	1,134	11,751	-9,540
Sales-scrappage response (-1)	96	-1,641	1,047	449	-925	1,068	117,888	-2,475
AEO 2025 sales	62	-1,031	683	302	-927	1,118	30,895	-4,733
No fleet share price response	96	-1,567	1,049	472	-925	1,108	47,245	-7,432
Fixed fleet share	95	-1,597	1,044	469	-921	1,105	47,099	-7,334
Fixed fleet share, no price response	96	-1,567	1,049	472	-925	1,108	47,245	-7,432
Mass-size-safety (low)	96	272	1,052	473	-925	1,112	47,133	-7,185
Mass-size-safety (high)	96	-3,402	1,052	473	-925	1,112	47,133	-7,185
Crash avoidance (low)	96	-1,642	1,052	473	-925	1,112	47,133	-7,185
Crash avoidance (high)	96	-1,452	1,052	473	-925	1,112	47,133	-7,185
2019 EPA Domestic Only CO_2	96	-1,567	1,052	473	-925	1,112	47,133	-7,185
2019 EPA Domestic Only CO_2, CH_4, N_2O	96	-1,567	1,052	473	-925	1,112	47,133	-7,185
AMPC 2026-2031	96	-1,567	1,052	473	-925	1,112	46,609	-7,242

No vehicle reclassification	94	-1,529	1,027	461	-910	1,091	46,470	-7,033
Reclassified vehicles in No-Action Alternative	114	-1,842	1,245	559	-1,116	1,304	58,040	-8,147
AC/OC phase-out in 2032	96	-1,568	1,052	473	-925	1,112	47,123	-7,185
No AC-OC in No-Action Alternative	107	-1,729	1,170	526	-1,038	1,241	53,051	-8,149
Proposed standards (2022-2026)	101	-1,654	1,105	496	-972	1,163	49,729	-7,503

Table 9-6: Penetration Rates of Selected Technologies for the Preferred Alternative (Alt. 2), by Sensitivity Case (Percent, MY 2031)

Sensitivity case	HCR		SHEV		PHEV	
	No-Action	Change	No-Action	Change	No-Action	Change
Central analysis	6.9	+9.5	80.2	-27.8	7.3	-1.8
Annual vehicle redesigns	11.0	+9.1	78.1	-14.3	7.3	-4.4
No advanced engines	6.9	+9.5	80.2	-27.4	7.3	-1.8
Oil price (high)	7.3	+9.0	79.8	-25.2	7.3	-1.8
Oil price (low)	6.9	+9.5	80.2	-30.6	7.3	-1.8
GDP (high)	6.8	+9.7	80.3	-28.1	7.3	-1.8
GDP (low)	7.0	+9.3	80.1	-27.7	7.3	-1.8
Oil market externalities (low)	6.9	+9.5	80.2	-27.8	7.3	-1.8
Oil market externalities (high)	6.9	+9.5	80.2	-27.8	7.3	-1.8
Fuel reduction import share (50%)	6.9	+9.5	80.2	-27.8	7.3	-1.8
Fuel reduction import share (100%)	6.9	+9.5	80.2	-27.8	7.3	-1.8
No payback period	6.7	+9.7	80.3	-36.0	7.3	-1.8
24-month payback period	6.9	+9.5	80.2	-31.3	7.3	-1.8
30-month payback period	6.9	+9.5	80.2	-29.5	7.3	-1.8
60-month payback period	6.2	+10.4	81.4	-21.3	7.3	-1.8
Rebound (10%)	6.9	+9.5	80.2	-27.8	7.3	-1.8
Rebound (20%)	6.9	+9.5	80.2	-27.8	7.3	-1.8
Sales-scrappage response (-0.1)	6.9	+9.5	80.2	-27.8	7.3	-1.8
Sales-scrappage response (-1)	6.9	+9.5	80.2	-27.8	7.3	-1.8
AEO 2025 sales	6.9	+9.6	80.2	-27.9	7.3	-1.8
No fleet share price response	6.9	+9.5	80.2	-27.8	7.3	-1.8
Fixed fleet share	6.8	+9.9	80.3	-27.8	7.1	-1.7
Fixed fleet share, no price response	6.9	+9.5	80.2	-27.8	7.3	-1.8
Mass-size-safety (low)	6.9	+9.5	80.2	-27.8	7.3	-1.8
Mass-size-safety (high)	6.9	+9.5	80.2	-27.8	7.3	-1.8
Crash avoidance (low)	6.9	+9.5	80.2	-27.8	7.3	-1.8
Crash avoidance (high)	6.9	+9.5	80.2	-27.8	7.3	-1.8
2019 EPA Domestic Only CO_2	6.9	+9.5	80.2	-27.8	7.3	-1.8
2019 EPA Domestic Only CO_2, CH_4, N_2O	6.9	+9.5	80.2	-27.8	7.3	-1.8
AMPC 2026-2031	6.9	+9.5	80.2	-27.8	7.3	-1.8
No vehicle reclassification	6.9	+9.5	80.2	-27.3	7.3	-1.8
Reclassified vehicles in No-Action Alternative	1.0	+14.2	87.9	-34.4	7.3	-1.8
AC/OC phase-out in 2032	6.9	+9.5	80.2	-27.8	7.3	-1.8

No AC-OC in No-Action Alternative	4.4	+11.9	84.3	-31.8	7.3	-1.8
Proposed standards (2022-2026)	6.7	+10.9	80.3	-29.3	7.3	-1.8

9.2.2. Effect of Technology- and Safety-Related Parameters

9.2.2.1. Redesign Schedules

Vehicle manufacturers establish redesign schedules for their vehicles based on many factors, including the availability of capital and other resources, competitive position in certain market segments, the sales volume for each vehicle model, and regulatory requirements. As discussed in preamble Section II.C, NHTSA uses an informed, historical review of redesign and refresh intervals to estimate future redesign and refresh intervals. However, the nature of automotive refresh and redesign cycles is not always consistent and can vary by model type, segment competitiveness, new entrants, or a manufacturer's capital availability, among other factors. To test an extreme case of redesign flexibility, one sensitivity case allows for annual vehicle redesigns, meaning each vehicle in the analysis fleet could be redesigned in each model year. In this setting, the pool of available vehicle and technology combinations is significantly greater for each manufacturer because there are more opportunities for vehicle redesigns than in the central analysis. This sensitivity case provides more opportunities within the CAFE Model to optimize technology solutions in response to a given set of parameters in each model year. More rapid redesigns would therefore allow manufacturers to hew closer to the regulatory requirements, as shown in Figure 9-5. When refresh cycles are less frequent, as has been observed empirically, manufacturers (with the knowledge that they will be unable to apply new technology until the next refresh or redesign) must apply technology to achieve compliance with future standards that will apply up until their next refresh or redesign occurrence. The CAFE Model simulates this behavior by considering the standard in an analysis year along with the unused technology candidates from the most recent refresh or redesign, then retroactively applies technology back to the most recent refresh or redesign if it is determined to be the most cost-effective way to reach compliance (See CAFE Model Documentation S5.3.2).

NHTSA cautions, however, that this sensitivity case represents a narrowly focused test of the impacts of the Model's logic and the impact of real world constraints rather than a realistic consideration of modeling uncertainty, as manufacturers have historically required multiple years of development between redesigns and refreshes. In addition, this case does not account for the costs of stranded capital from such high frequency redesigns, nor of scaling up of the facilities and development and design teams required to implement annual redesign schedules across the portfolio. These costs likely would be significant, and the CAFE Model does not currently estimate or incorporate these into overall program cost estimates. Manufacturers control the redesign schedules for their own vehicles and the fact that they still require multiple years between redesigns despite the potential benefits of shorter cycles points to there being technical, practical, and economic obstacles to doing so.

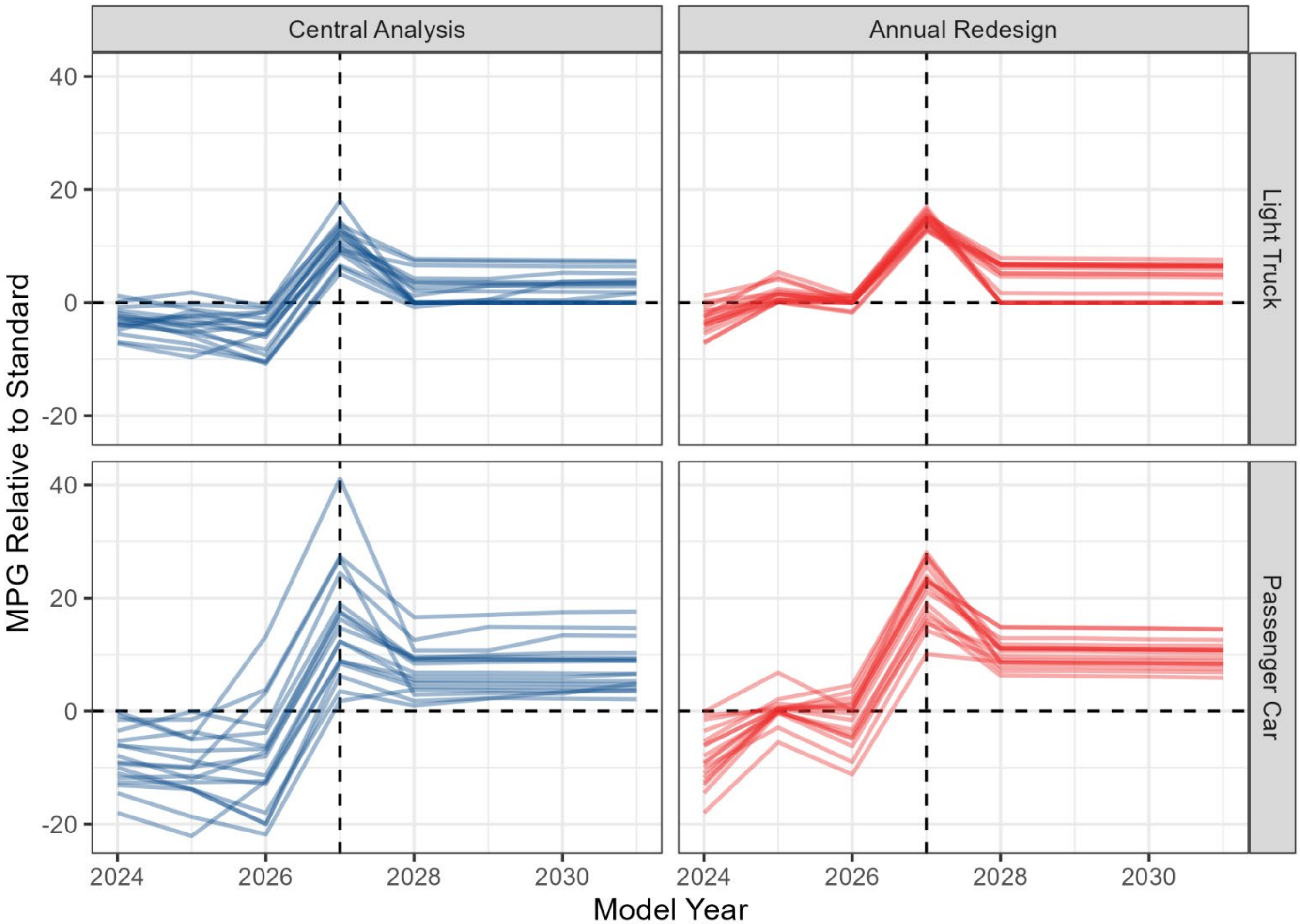
The impact of annual redesign compared to the redesign assumptions in the central analysis for the Preferred Alternative results in:

- Cost increases by $55.7 billion at the 3-percent discount and by $39.3 billion at the 7-percent discount rate, benefits increase by $55.4 billion at the 3-percent discount rate and $35.4 billion at the 7-percent discount rate, and net benefits decrease by $0.3 billion at the 3-percent discount and $3.9 billion at the 7-percent discount rate.
- Projected gasoline consumption declines by 39 billion gallons at both the 3- and 7-percent discount rate.
- Estimated regulatory costs decrease by $481 per vehicle.
- SHEVs increase by 13.5 percent light duty fleet share and PHEVs decrease by 2.6 percent light duty fleet share in MY 2031.

Figure 9-5 below shows the compliance status relative to the standard for each manufacturer by model year across regulatory classes; a value of zero indicates that the achieved compliance is equal to the standard, positive values indicate over-compliance, and negative values indicate under-compliance. The left panels show the central analysis, and the right panels show the annual redesign sensitivity case. Overall, in the central analysis, most manufacturers must apply technology to achieve compliance ahead of increases in the

CAFE standard. In contrast, for the annual redesigns, most manufacturers hew closer to the MPG standard, with no manufacturers failing to meet the standard in the standard-setting years. Thus, for regulatory years where the CAFE standard increases, annual redesigns predict lower (but still compliant) fuel economy as manufacturers apply the minimum of technology every year to meet the standard.

Figure 9-5: Compliance Paths for Central Analysis and Annual Redesign Sensitivity Case



Each line represents a manufacturer's compliance path.
Presentation omits Ferrari and Ineos.

9.2.2.2. No Advanced Engines

Another sensitivity case examines whether certain engine technologies are being applied unnecessarily by the CAFE Model and raising tech costs. For this sensitivity, NHTSA applies additional technology SKIPs in the Market Data Input File to block the application of the advanced engine technologies, as well as micro and mild hybrid technologies, for all vehicles that did not include those technologies in the MY 2024 baseline fleet. These technologies include advanced cylinder deactivation with single overhead camshaft, advanced cylinder deactivation with dual-overhead camshaft, turbocharged engine with cylinder deactivation, turbocharged engine with advanced cylinder deactivation, variable turbo geometry, variable turbo geometry (electric), variable compression ratio, DSLI, 12VSS, and BISG.

For this sensitivity case, the average regulatory cost on a per vehicle basis for the Preferred Alternative in MY 2031 is unchanged from the central analysis for the 3-percent discount rate and increases by $9 for the 7-percent discount rate. Estimated net benefits increase by $100 million (shown in billions of $ in Figure 9-1) for the 3-percent discount rate and are about $100 million lower under the 7-percent discount rate compared to the reference case for the Preferred Alternative. Retail fuel expenditure in dollars per vehicle is reduced by

$29 with the 3-percent discount rate and by $22 with the 7-percent discount rate when compared to the central analysis estimate for the Preferred Alternative. There is also a 0.4-percent increase in SHEV adoption in the fleet over the reference case for the Preferred Alternative.

The data presented in Chapter 9.2.1 shows the minimal impact of restricting advanced engine and micro and mild hybrid technologies within the analysis.

9.2.2.3. Mass-Size Safety and Crash Avoidance

Estimates in the central analysis regarding the future safety impacts of CAFE requirements reflect NHTSA's best judgment regarding the evolution of factors that affect vehicle safety. Nevertheless, there is uncertainty regarding the values applied to the CAFE safety analysis. These uncertainties include: (1) the joint effects of the mass effects modeled across vehicle classes and (2) the effectiveness of crash avoidance technologies. To address these uncertainties, NHTSA performs four sensitivity analyses that adjust underlying safety parameters for the fleet. Table 9-7 and Table 9-8 provide values for the number of fatalities, total costs, and total benefits estimated in the central analysis and changes in those estimates under each sensitivity case. Below those values, the table provides the difference in these outcomes when different safety assumptions are compared to the central analysis.[162] In each of the following sensitivity cases, all inputs are held constant other than the noted safety parameter. The models use a 3- and 7-percent discount rate for dollar valuations. Fatalities are not discounted.

(1) Adjustments to the mass parameters influence the assumed average mass disparity between vehicles in crashes. Changes in mass of vehicles near the median of the distribution of curb weight have a relatively small effect on total fatalities, which can be positive or negative; broad upward shifts in vehicle mass lead to reductions in fatalities associated with the heaviest non-passenger automobiles that are offset by increases in fatalities associated with the lightest passenger automobiles. It is important to note, as discussed in Draft TSD Chapter 7.3.3, the mass-safety parameters estimated from statistical models used in the CAFE analysis are statistically indistinguishable from zero. The gain in net social benefits from assuming a high mass safety effect is $22.7 billion. Conversely, the loss from assuming a low mass safety effect is a $22.7 billion reduction relative to the central analysis. The mass size sensitivities represent two standard deviations below and above the point estimates of the mass size safety parameters. The range covered by these extreme values greatly exceeds the estimated effect of mass size safety in the regulatory alternatives in the main analysis discussed in PRIA Chapter 8.4.4. Total safety costs across alternatives analyzes range in absolute magnitude from $33.2 to $37.3 billion dollars.

(2) Some crash avoidance technologies are nascent, and there is some uncertainty about the future effectiveness of these technologies. Higher technology effectiveness rates tend to increase the costs of delaying new vehicles from entering the fleet. Lower technology effectiveness rates tend to reduce the costs of slowing vehicle turnover, since the relative safety difference between new vehicles and old vehicles on the road decreases. Greater VMT magnifies the impact of these technologies (fewer fatalities under the No-Action Alternative), while lower VMT lessens their impact. Thus, the results in Table 9-7 are primarily driven by the reduction in aggregate VMT as a result of the reset standards. Under the sensitivity case assuming low effectiveness of these technologies there would be 75 fewer fatalities while under a scenario with high technological effectiveness there would be an additional 115 deaths. The increase in net social benefits from assuming a low technological effectiveness is slightly more than $100 million; conversely, the loss from assuming a high technological effectiveness is less than $100 million dollars relative to the central analysis. These results derive from the fact that fuel economy is higher in the No-Action baseline than in the alternatives in the analysis. Lower effectiveness of ADAS technologies results in more crashes from the rebound effect on VMT in the No-Action Alternative. This makes the safety differences between the No-Action Alternatives and regulatory alternatives more pronounced. Conversely, higher crash avoidance from ADAS systems lessens the impact of higher rebound VMT on crashes. This makes the safety differences between the No-Action Alternative and regulatory alternatives less pronounced.

[162] While changes in the safety parameters affect fatalities, non-fatal injuries, and property damage crashes, Table 8-10 shows only differences in fatalities. Changes in net social benefit of each scenario include the social value of non-fatal injuries and property damage crashes attributable to changes in the sensitivity parameter.

Table 9-7: Relative Differences Between Central Analysis and Sensitivity Cases, 3% Discount Rate

	Light-Duty			
Scenario	**Fatalities**	**Total costs ($b)**	**Total benefits ($b)**	**Net benefits ($b)**
Central analysis	-1,567	-109.1	-85.1	24.0
Sensitivity Cases	**Difference From Reference Case**			
Mass-size-safety (low)	1,834	23.9	1.2	-22.7
Mass-size-safety (high)	-1,835	-23.9	-1.2	22.7
Crash avoidance (low)	-75	-1.5	-1.3	0.1
Crash avoidance (high)	115	0.9	0.9	-0.1

Table 9-8: Relative Differences Between Central Analysis and Sensitivity Cases, 7% Discount Rate

	Light-Duty			
Scenario	**Fatalities**	**Total costs ($b)**	**Total benefits ($b)**	**Net benefits ($b)**
Central analysis	-1,567	-76.0	-53.8	22.2
Sensitivity Cases	**Difference From Reference Case**			
Mass-size-safety (low)	1,834	14.8	0.7	-14.1
Mass-size-safety (high)	-1,835	-14.8	-0.8	14.1
Crash avoidance (low)	-75	-0.9	-0.8	0.1
Crash avoidance (high)	115	0.6	0.5	0.0

9.2.3. Effect of Economic Parameters

9.2.3.1. Oil Prices

One of the most significant sources of uncertainty in this analysis is the future cost of fuel. Fuel costs affect the value of fuel savings both in the year when new vehicles are produced and in subsequent years when vehicles are used. NHTSA has simulated two sensitivity cases based on the 2025 EIA AEO's high oil price and low oil price side cases.

The results are in line with expectations. The high oil price scenario results in somewhat lower net benefits in the Preferred Alternative, decreasing by $4.4 billion, while the low oil price case results in markedly higher net benefits, increasing by $12.1 billion. Higher oil prices may also increase the level of technology adoption in both the No-Action Alternative and in the regulatory alternatives, as more expensive technologies may become cost effective when fuel prices are higher. In the Preferred Alternative, the SHEV penetration rate is slightly higher under the high oil price scenario compared to the central analysis, and somewhat lower in the low oil price scenario.

9.2.3.2. Macroeconomic Forecasts

The CAFE Model relies on a set of macroeconomic assumptions related to GDP growth, U.S. population, real disposable personal income, and consumer confidence to simulate the economic context in which CAFE regulations are implemented. These values affect the projected size of the new light duty vehicle market, the rate at which the on-road fleet turns over, and the total demand for travel as documented in Draft TSD Chapter 4. The central analysis assumptions come from the EIA AEO 2025 and the S&P Global GI September 2024 Macroeconomic Outlook base case. For the sensitivity cases, NHTSA uses the March 2025 S&P forecast's high- and low-GDP growth cases' estimates of GDP, population, number of households, consumer sentiment, and real disposable income. The "GDP (low)" and "GDP (high)" sensitivity cases in the tables and figures of Chapter 9.2.1 refer to the implementation of those two growth cases in the CAFE Model. To help isolate the effects of varying these input components, these cases hold fuel prices fixed at the central analysis level.

NHTSA finds only minor impacts from these changes in projections. Under the more optimistic projection, net benefits are around $100 million higher, while using the more pessimistic forecast leads to net benefits falling by about $2.7 billion. These parameters have little impact on compliance behavior by the manufacturers, and so regulatory costs and technology penetration are generally in line with the central analysis case.

9.2.3.3. Oil Market Externalities and Import Share

For the proposed rule analysis, NHTSA estimates the value of externalities from fuel consumption related to energy security in oil markets. As explained in Draft TSD Chapter 6.2.4.6, these quantities depend on the short run elasticities of global and domestic petroleum supply and demand, as well as the elasticity of U.S. GDP with respect to global oil prices. There are a range of estimates for these quantities in the literature, and thus a range of potential values for the estimates of energy security externalities. In the central analysis, NHTSA uses the mean estimates produced from the full set of possible elasticity parameterizations.[163] To evaluate the sensitivity of the CAFE Model results to this parameter, the agency has run two additional cases in which value of oil market externalities is set to the lower 10th percentile value, and the higher 90th percentile value.

Since this quantity measures the value of a societal effect that is not internalized by vehicle owners or manufacturers, there are no effects on the simulated compliance behavior of manufacturers or on the driving behavior of owners from varying this parameter. Instead, variation of this parameter simply scales up or down the societal effect of a change in the quantity of oil consumption induced by a regulatory alternative, and thus only affects the overall benefits from a change in regulation and not the costs. In Table 9-2 the analysis shows that using the high estimate for the externality removes about $2.5 billion dollars of additional estimated benefits, while using the low value increases estimated benefits by around $2.0 billion.

For the proposed rule, NHTSA assumes that 80 percent of the reduction in fuel consumption is accounted for by reductions in fuel imports. This is calibrated using a simple model of the global fuel market described in Draft TSD Chapter 6.2.4.5. NHTSA also assesses two alternative assumptions of the effects of a reduction in fuel consumption as sensitivity cases: (1) an assumption that 50 percent of the reduction in fuel consumption leads to reduced fuel imports and (2) an assumption that 100 percent of the reduction in fuel consumption leads to reduced imports (rather than effects on domestic production). The primary channel through which this assumption affects net benefits is through the quantity by which domestic upstream emissions are

[163] NHTSA takes its estimates for these elasticities from the distribution of elasticity estimates listed in Brown, S., New Estimates of the Security Costs of U.S. Oil Consumption, Energy Policy, Vol. 13: pp. 171-92 (2018), available at: https://doi.org/10.1016/j.enpol.2017.11.003 (accessed: Sept. 10, 2025). This set includes both recent and older estimates of these elasticities.

changed. Impacts on societal net benefits are small in each case, with net benefits rising by $400 million in the 100-percent case and falling by $600 million in the 50-percent case.

9.2.4. Effect of Payback, Mileage, and Fleet Composition Parameters

9.2.4.1. Payback Period

The current analysis characterizes buyers' preference for fuel economy improvements by the amount of time required to offset the initial technology investment with avoided fuel costs—the payback period. The central analysis uses a 36-month payback period to quantify the average preference for fuel economy improvements in the new vehicle market. To examine the effect of this payback period, the sensitivity cases include a range of alternative payback period lengths (24-, 30-, and 60-month scenarios) as well as one case that eliminates the consideration of a payback period entirely. With a longer required payback period, more costly technologies that offer fuel efficiency improvements would be more attractive options to both manufacturers and consumers. More effective technologies will have higher fuel cost savings but, with shorter assumed payback periods, there still may not be enough time to accumulate sufficient fuel savings to offset the higher initial cost.

In the 60-month payback period scenario, incremental average vehicle costs, lifetime fuel savings, total benefits, and total costs (relative to the No-Action Alternative) all decrease in magnitude when compared to the central analysis. Longer payback periods mean consumers are more willing to pay for technology that improves fuel efficiency. As a result, estimated net benefits for the Preferred Alternative would be lower, at $17.8 billion. Conversely, assuming no payback period exists would result in manufacturers declining to adopt fuel-saving technology for any reason other than to comply with fuel economy standards, since consumer purchase decisions would be unaffected by the vehicle's fuel economy at all. Net benefits move as expected in these two cases, increasing to $37.4 billion when the analysis eliminates the payback period entirely.

When the payback period is shortened to 24 months, manufacturers produce fewer vehicles with more expensive technology (e.g., SHEVs) in the regulatory alternatives. This keeps the incremental change in SHEV penetration in this case lower than in the central analysis. Net benefits under the Preferred Alternative are higher than for the Preferred Alternative in the central analysis.

The 30-month payback period produces somewhat more negative incremental social costs and social benefits than the central analysis case. NHTSA previously has used a 30-month payback period assumption and finds that its results are not sensitive to this change, as net-benefits vary only by around $1.4 billion.

9.2.4.2. Rebound Effect

The CAFE Model results are less sensitive to some parameters than others. As seen in Table 9-2 and Table 9-3, changing the rebound effect in either direction has a moderate impact on net benefits under the Preferred Alternative. The central analysis uses a rebound effect of 15 percent, and the two sensitivity cases assume 10- and 20-percent rebound. Changing the rebound effect parameter increases or decreases the amount of incremental fuel cost in the Preferred Alternative by little over $30 per vehicle (decrease when rebound is lowered, increase when rebound is increased), but those changes are due to changes in travel that provide corresponding mobility benefits that offset the change in fuel costs.

Using a 3-percent discount rate, assuming a rebound effect of 10 percent results in more negative incremental costs and benefits, relative to the central analysis, and an increase in net benefits. Assuming a rebound effect of 20 percent leads to less negative incremental cost and benefit values and a decrease in net benefits relative to the central analysis. In both cases, estimated net benefits change by about $2.3 billion.

9.2.4.3. Sales Response

The sensitivity cases with adjusted sales and scrappage responses produce marked changes in costs and benefits. NHTSA includes two cases with different sales-scrappage responses, which vary the price elasticity around the price elasticity parameter above and below the value used for the central analysis. The high elasticity case uses a price elasticity of -1, and the low elasticity case uses -0.1.

The effects of this variation on net benefits are significant. As shown in Table 9-2 net benefits in the low elasticity case for light duty vehicles are lower by about $6.5 billion, while they are higher by about $13.0 billion in the high elasticity case. A more elastic consumer response depresses sales to a greater extent when technology costs are passed through to consumers, meaning that the estimated regulatory cost savings are increased when the new vehicle market is more elastic.

9.2.4.4. Fleet Share

In this analysis, NHTSA has chosen to project the baseline fleet share forward from the 2024 initial fleet using the year-to-year growth rate projections implied by the AEO 2025 Alternative Transportation Case for the central analysis. To account for the influence of relative price changes between passenger automobiles and non-passenger automobiles across regulatory alternatives, NHTSA uses a parameterized binomial logit model, which is described in further detail in Draft TSD Chapter 4.2 and in a docket memo.[164] To test the sensitivity of the CAFE Model's results to these modeling choices, the agency has run three additional cases: (1) using the AEO-based share projection but excluding the price-based adjustment between regulatory alternatives; (2) keeping the No-Action Alternative fleet share fixed at 2024 levels but allowing price-based adjustments in the alternatives; and (3) keeping fleet shares in each alternative fixed at the 2024 levels, and excluding the price-based adjustment.

As shown in Table 9-2, excluding the price-based adjustment has little influence on the estimated incremental costs and benefits of the regulatory alternatives. The same can be said for fixing the fleet share at 2024 levels, though net benefits are now slightly lower compared to the central analysis. In the combined case of fixing the fleet share and not allowing a price response, net benefits increase by about $200 million under the 3-percent discount rate. The increase in net benefits is largest under Alternatives 1 and 2. Note that removing this adjustment limits the reallocation of non-rebound VMT, and thus safety costs, between passenger automobiles and non-passenger automobiles, as described in Draft TSD Chapter 4.3.

9.2.4.5. Sales Forecasts

The central analysis uses a nominal forecast to project total CAFE fleet sales.[165] To test the sensitivity of the CAFE Model to these modeling choices, NHTSA runs a sensitivity case for the gas-powered share of vehicle sales growth projections of CAFE fleet vehicles. This case deals specifically with either methodological or input choices that directly impact the No-Action Alternative sales projections. However, sensitivities that adjust macroeconomic variables (the “GDP High” and “GDP Low” cases) also will affect the projected level of sales for light duty vehicles in the No-Action Alternative and the regulatory alternatives. Thus, sensitivity to changes in No-Action Alternative sales can be seen as being embedded in this additional sensitivity case as well.

For the central analysis, sales are projected using the AEO 2025 Alternative Transportation Case's year-to-year gas-powered light duty sales growth rates, which are applied to the initial compliance fleet used in the CAFE Model. In this sensitivity case, NHTSA uses the AEO 2025 Reference Case's projection instead. Since these changes do not affect the costs or benefits of technology adoption for an individual vehicle, they just tend to amplify or decrease the levels of net benefits observed in the central analysis. Examining their effect on costs and benefits in Table 9-2 **Error! Reference source not found.**shows that this is the case. Net benefits under a 3-percent discount rate decrease by about $5.2 billion under Alternatives 1 and 2, and decrease by $5.1 billion under Alternative 3, relative to the reference case.

9.2.5. Effect of Policy and Other Assumptions

9.2.5.1. Classification

In the central analysis, NHTSA modeled the effects of the proposed vehicle reclassification and change in stringency jointly. NHTSA developed alternative versions of its preferred alternative to decompose these effects. NHTSA notes, however, that the outcomes of any of these model runs are only presented for

[164] See Calibrated Estimates for Projecting Light-Duty Fleet Share in the CAFE Model, Docket No. NHTSA-2023-0022.
[165] The nominal forecast predicts total sales for gas-powered light-duty vehicles in the No-Action Alternative. This model is described in detail in TSD Chapter 4.2.

awareness. Put another way, the costs or benefits of any decoupled model run are not driving the reclassification proposal: NHTSA's proposal to amend its vehicle classification definitions is founded solely on the fact that the current classification regulations are not based on the best reading of the statute. This is discussed in preamble Section VI.B.1 Modification of Vehicle Classification in the CAFE Program. For this decomposition, NHTSA examined the effects of two additional analyses: (1) changing standards without reclassifying vehicles; and (2) reclassifying vehicles without lowering stringency.

Table 9-9 shows the costs and benefits associated with each auxiliary analysis. Changing stringency without vehicle reclassification increases benefits and costs relative to the $24.0 billion in net benefits of the central analysis and results in net benefits of $23.9 billion, or approximately $167 million dollars higher than the central analysis. Regulatory costs and additional fuel costs are changed little from the results in the central analysis.

Reclassification without the accompanying change in stringency leads to positive benefits and costs relative to the No-Action Alternative. Keeping stringency at the No-Action Alternative's level and reclassifying vehicles from the light truck to passenger car fleet exposes those reclassified vehicles to a higher standard and thus forces additional technology costs while generating additional fuel savings. Overall, this reduces net benefits from $24 billion in the central analysis to negative $7.0 billion. This case generates additional regulatory costs in the baseline and increases the incremental regulatory cost savings and fuel expenditures in the action alternatives.

Table 9-9: Individual Effects of the Components of the Proposal on Costs and Benefits (MYs 1985-2031)

Effect	Total Benefits ($b)	Total Costs ($b)	Net Benefits ($b)
Central analysis	-85.1	-109.1	24.0
Stringency change without reclassification	-84.0	-107.9	23.9
Reclassification without reduced stringency	14.1	21.1	-7.0

9.2.5.2. Advanced Manufacturing Production Credit 2026-2031

NHTSA has performed a single sensitivity on including the IRA's AMPC for MYs 2026-2031. Net benefits increase by $100 million (shown in billions of $ in Figure 9-4 and Table 9-2) at the 3-percent discount rate and increase by $100 million (shown in billions of $ in Table 9-3) at the 7-percent discount rate with the Preferred Alternative in the sensitivity case compared to the central analysis. There is no change in hybridization technology penetration and virtually no change in the fleet model metrics. However, there are 524 fewer vehicles sold in 2031 and 57 fewer jobs in the same year at both the 3- and 7-percent discount rates.

9.2.5.3. Air Conditioning/Off-Cycle Phase-Out

In its 2024 final rule,[166] NHTSA amended its regulations to align with the changes EPA made to its AC efficiency and OC programs in its 2024 final rule.[167,168] In that final rule, EPA restricted manufacturers' ability to earn OC credits to only the technologies in the OC menu starting with MY 2027. In addition, EPA finalized a phase-out of the OC menu credits by reducing the OC cap year-over-year until the credits are fully phased out in MY 2033. Specifically, EPA set a declining menu credit cap of 10/8/6/0 grams per mile (g/mile) over MYs 2030-2033—with MY 2032 being the last year manufacturers could generate OC menu credits. In that final rule, EPA also continued to set the AC efficiency credit cap at 5 g/mi for MY 2027 and beyond. Finally, EPA restricted the ability to earn AC efficiency and OC credits to only ICE vehicles in MY 2027 and beyond.

[166] 89 FR 52926 (June 24, 2024).
[167] 89 FR 27916 (Apr. 18, 2024).
[168] 89 FR 27919 (Apr. 18, 2024).

For this proposal, NHTSA developed a sensitivity case to determine the impact of continuing with the OC and AC efficiency program provisions the agency adopted in its 2024 final rule.

Based on the data in Chapter 9.2.1, NHTSA determined that continuing to consider AC efficiency and OC technology FCIVs in line with EPA's current provisions to phase out OC menu credits in MY 2032 and set the AC efficiency credit at 5 g/mi in MY 2027 for ICE vehicles in MY 2027 and beyond would have no impact on the results of this rulemaking analysis. Specifically:

- The average regulatory cost on a per-vehicle basis for the Preferred Alternative in MY 2031 remains unchanged from the central analysis for the 3- and 7-percent discount rates.
- The estimated net benefits for the Preferred Alternative in MY 2031 remain unchanged from the central analysis for the 3- and 7-percent discount rates.
- Retail fuel expenditures in dollars per vehicle for the Preferred Alternative in MY 2031 remain unchanged from the central analysis for the 3- and 7-percent discount rates.
- The light duty fleet penetration of HCR, SHEV, and PHEV technologies for the Preferred Alternative in MY 2031 remains unchanged from the central analysis.

9.2.5.4. Proposed Standards (2022-2026)

Applying the proposed standards for MYs 2022-2026 (Alternative 2) within the CAFE Model simulation, rather than the standards that prevailed in those years, compared to the central analysis for the Preferred Alternative through MY 2031 results in estimated costs decreasing by $5.9 billion for the 3-percent discount rate and decreasing by $4.2 billion at the 7-percent discount rate. Estimated benefits also decrease by $4.1 billion in the 3-percent discount rate and $2.7 billion at the 7-percent discount rate. Net benefits increase by at least $1.5 billion at both the 3- and 7-percent discount rates. Gasoline consumption increases by 5 billion gallons and the regulatory cost per vehicle decreases by $47. However, retail fuel expenditure per vehicle increases by $64 at the 3-percent discount rate and $51 at the 7-percent discount rate. Under this sensitivity case, HCR technology penetration would increase by 10.9 percent and SHEVs would be reduced by 29.3 percent when compared to the No-Action Alternative. When compared to the central analysis, this is approximately a 1.4-percent increase in HCR technology and a roughly 1.5-percent decrease in SHEVs.