# Reconsideration of 2009 Endangerment Finding and Greenhouse Gas Vehicle Standards

## Draft Regulatory Impact Analysis

United States
Environmental Protection
Agency

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Office of Transportation and Air Quality
U.S. Environmental Protection Agency

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United States Environmental Protection Agency

EPA-420-D-25-003
July 2025

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# 1 Introduction

This Draft Regulatory Impact Analysis (DRIA) contains an analysis of projected impacts for the proposed removal of all U.S. Environmental Protection Agency (EPA) greenhouse gas (GHG) standards for light-duty (LD), medium-duty (MD) and heavy-duty vehicles (HD) and HD engines as outlined in the preamble to the *Federal Register* notice associated with this document in accordance with Executive Orders (E.O.) 12866 and 13563. As stated in the preamble for this rule, the EPA recognizes that there have been a number of significant changes since we issued the spring 2024 rulemakings for the Light- & Medium-Duty Vehicle Multipollutant final rule (LMDV)[1] and the Heavy-Duty Vehicle GHG Phase 3 final rule (HD GHG Phase 3)[2] which impact the technical assessment in those two actions, including, but not limited to, the EPA's 2024 assessment of program costs and benefits. Some of the assumptions we no longer believe are appropriate and would significantly impact the costs and benefits of this proposed rule include, but are not limited to:

- The impact and existence of electric vehicle (EV) related tax credits and other subsidies from the 2022 Inflation Reduction Act (IRA) which have been changed by the 2025 One Big Beautiful Bill (OBBB);
- The impact of the EPA's waiver rule of California's Advanced Clean Truck (ACT) regulation that has been disapproved under the Congressional Review Act (CRA) and is no longer in force;
- Changes in consumers' interest in purchasing EVs;
- Recent projections of future gasoline and diesel prices from the U.S. Energy Information Administration (EIA) as well as changes in Administration and policies; and
- Changes in the power generation sector as a result of recent projections for data center demands and changes in the OBBB, and the impacts of increased use of EVs.

This document contains discussions of some of the key assumptions that supported the technical analysis contained in the LMDV and HD GHG Phase 3 rulemakings (2024 vehicle rulemakings), and how those assumptions may be different today. Specifically:

- Chapter 2 summarizes information which has become available since the spring of 2024 regarding changes in consumers' and commercial purchasers' interest in batteryEVs (BEVs), as well as recent third-party studies' assessments of how changes in policies may impact the U.S. EV market;
- Chapter 3 discusses recent projections in gasoline and diesel fuel prices and compares those projections to the data the EPA used in the 2024 vehicle rulemakings;
- Chapter 4 discusses the projections the EPA made regarding the power generation sector changes needed to support the increased electrification of the vehicle fleet estimated in the 2024 vehicle rulemakings, and how those projections may change in light of more recent information; and

[1] 89 FR 27842 (Apr. 18, 2024) "Multi-Pollutant Emissions Standards for Model Years 2027 and Later Light-Duty and Medium-Duty Vehicles."
[2] 89 FR 29440 (Apr. 22, 2024) "Greenhouse Gas Emissions Standards for Heavy-Duty Vehicles-Phase 3."

- Chapter 5 discusses existing literature on how LD consumers value savings due to fuel saving technology and the EPA's treatment of fuel savings in previous rulemakings.

In recognition of these and other changes since the 2024 vehicle rulemakings, in Chapter 6 the EPA presents the estimated impacts of removing the GHG standards from LD, MD, and HD vehicles and HD engines. These results are estimated using two different methodologies and a total of seven different modeled scenarios. One method uses the same models and tools used to estimate the impacts of the 2024 vehicle rulemakings. We present five scenarios using these models and tools: 1) impacts using the same assumptions as the 2024 vehicle rulemakings; 2) impacts assuming the removal of IRA tax credits and the ACT rule; 3) impacts assuming the removal of those policies as well as reduced fuel prices; 4) impacts of scenario 2 accounting only for the first two and half years of fuel savings; and 5) impacts of scenario 3 accounting only for the first two and half years of fuel savings. More information on these scenarios is contained in Appendix A. The second method describes and presents two scenarios that attempt to capture some of the multiple opportunity costs created by the LD, MD, and HD GHG standards using a revealed preference approach to estimate the costs and benefits of this proposed action. Appendix B contains more information on this method, as well as on the aggregate reduced form representations of consumer behavioral responses and shifts in related markets. More information on this method is contained Appendix B.

Chapter 7 contains our analysis of small business entities that are subject to the LD, MD, and HD GHG emission standards and related regulations we propose to remove.

# 2 Changes in assumptions related to customers' interest in purchasing electric vehicles

There is indication that consumer/purchaser demand for LD, MD, and HD EVs has decreased below the levels projected in the 2024 vehicle rulemakings. Recent uncertainty related to the continued existence of tax credits established by the IRA have also led to reduced projections of demand for these EVs.

For LD vehicles, a recent survey from the American Automobile Association (AAA) representing the U.S. population indicates that fewer adults in 2024 reported they were "likely" to purchase a BEV compared to the previous year.[3] The reasons cited include many of the same issues consumers have historically been concerned with: high purchase price, high battery maintenance costs, and range concerns. Other concerns cited include lower gas prices, an increasingly uncertain future of EV incentives, and politics. A survey from JD Power representing U.S. consumers planning to buy or lease a vehicle in the next year indicates that the percent of vehicle shoppers who are at least somewhat interested in buying an EV in early 2025 is the same as a year ago, and that EV sales have increased compared to last year – potentially due to concerns about the EV tax credit being

[3] Moye, B. (2025). AAA: Americans Slow to Adopt Electric Vehicles. *American Automobile Association*: https://newsroom.aaa.com/2025/06/aaa-ev-survey/.

eliminated.[4] The survey also indicates that there is continued concern with charging. A Gallup poll from March 2025 indicates that the percentage of Americans who either own or express interest in ( seriously considering or might consider) owning an EV declined in 2024 compared to the previous year, and remains steady at the 2024 levels today, though the portion of those who say they are seriously considering purchasing an EV has declined since 2024.[5]

A study from Princeton University's Zero-carbon Energy systems Research and Optimization Laboratory (ZERO Lab) looked at the impact of removing EPA tailpipe emission regulations and the IRA's federal clean vehicle tax credits.[6] They estimate that removing the emission regulations and the tax credits together will reduce the sales of BEVs by about 30 percent in 2027 and 40 percent in 2030, compared to retaining the emission regulations and tax credits. This corresponds to a slower increase in the BEV share of new LD vehicle sales, reducing the BEV share by approximately five percentage points in 2026 (to about 13 percent), and by approximately 14 percentage points in 2030 (to about 24 percent). The study also estimates that planned construction and expansion of EV assembly and battery cell manufacturing as well as existing assembly and manufacturing could be at risk of cancellation or closure.[7]

A recent study by the Salata Institute for Climate and Sustainability at Harvard University estimated the effect of a set of EV policy change scenarios on LD vehicles, including removing the IRA tax credits, terminating the waiver that allows California to set tighter emissions standards, and withholding the remaining unspent funds in the National Electric Vehicle Infrastructure (NEVI) Formula Program, as well as a series of combining different policies. [8] They find that all three scenarios, as well as the combination of different scenarios, lead to a reduction in the EV share of new vehicles sold. They also find that eliminating the EV tax credits for consumers buying new and used vehicles has the biggest effect on EV sales in the single scenarios they analyzed, reducing the EV share of new vehicle sales in 2030 by 6 percentage points.

For MD and HD vehicles, California's ACT and Advanced Clean Fleet (ACF) rules were expected to provide regulatory drivers for the production of HD zero EVs (ZEVs) and the purchase of HD ZEVs. Congress' decision under the CRA to disapprove the EPA's waiver for ACT, and California's January 2025 decision to withdraw the waiver request for ACF, ended both of those programs.

In recent discussions between the EPA and HD industry stakeholders, the HD original equipment manufacturers (OEMs) indicated that, while they still believe that HD ZEVs will continue to grow and they continue to invest in HD ZEVs, they expect the pace of growth to be significantly slower than

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[4] Thomhave, K. (2025). Consumers sustain interest in EVs but range anxiety still a concern. *Automotive Dive*: https://www.automotivedive.com/news/jd-power-ev-sales-consumer-interest-strong/748924/;J.D. Power. (2025). EV Purchase Consideration Holds Steady amid Market Uncertainty, J.D. Power Finds: https://www.jdpower.com/business/press-releases/2025-us-electric-vehicle-consideration-evc-study.

[5] Saad, L. (2025). U.S. Electric Vehicle Interest Steady at Lower 2024 Level. *Gallup*: https://news.gallup.com/poll/658964/electric-vehicle-interest-steady-lower-2024-level.aspx.

[6] Jenkins, J. (2025). Potential Impacts of Electric Vehicle Tax Credit Repeal on US Vehicle Market and Manufacturing. *Princeton University ZERO* Lab: https://doi.org/10.5281/zenodo.15001498.

[7] Domonoske, C. (2025). The fate of the EV tax credits depends on the GOP's megabill. *National Public* Radio: https://www.npr.org/2025/06/03/nx-s1-5414604/ev-tax-credits-republican-bill.

[8] The Salata Institute for Climate and Sustainability at Harvard University. (2025). Quantifying Trump's impacts on EV adoption: https://salatainstitute.harvard.edu/quantifying-trumps-impacts-on-ev-adoption/

they projected just a few years ago, and OEMs continue to lower projected EV sales volumes for model years (MYs) 2025 and later. OEMs suggest there is a range of reasons for lower EV demand, including higher purchase prices leading to unfavorable total cost of ownership, charging infrastructure limitations, current performance limitations of EV technology for many HD truck applications, supply chain uncertainty, potential changes in IRA incentives, and the lack of California's ACT and ACF programs.

A recent market update report from CALSTART supported the expectation of slower ZEV growth for much of the HD market.[9] CALSTART notes that zero emission truck (ZET) deployments have grown steadily since 2022, but there was a relative slowdown in the first six months of 2024. CALSTART states that the lack of growth can be attributed to many of the same reasons stated above, including high upfront costs and financing costs, underdeveloped private and public infrastructure, and policy uncertainty. They also note that though more MD and HD ZEVs were deployed in 2024 compared to 2023, these deployments were concentrated in a handful of states, and the ZEV share of new MD and HD registrations decreased from 2023. Furthermore, CALSTART showed that much of the ZEV deployments were concentrated in California or other states that adopted the ACT program. It is unclear if ZEV deployment will continue at the same level in those states without the regulatory driver of the ACT and ACF rules.

# 3 Estimates of future gasoline and diesel prices due to the change in Administration and related policies

Predicting future gasoline and diesel prices, specifically 10 – 15 years or more in the future, is difficult due to high uncertainty. Historically, the EPA has used the EIA's Annual Energy Outlook (AEO) to determine future gasoline and diesel prices for rulemaking. Due to unforeseen changes, including, but not limited to: (1) changes in U. S.' policies; (2) international incidents (e.g., wars); (3) changes in policies by international organizations (e.g., OPEC); and (4) changes in supply and demand of gasoline and diesel.

The 2024 vehicle rulemakings relied on the AEO assessment from the EIA for fuel prices. Specifically, we used the most recent version available at the time, AEO 2023, to project future fuel prices in those rules.[10] The AEO 2023 "Reference case" included considerations of the IRA as well as the EPA GHG and National Highway Traffic Safety Administration's (NHTSA) Corporate Average Fuel Economy (CAFE) standards that were in place at the time. EIA recently released the AEO 2025, which includes significant updates to the Reference case, as well as an alternative analysis for the transportation sector.

[9] Richard, J. (2025). Zeroing in on Zero-Emission Trucks: June 2025 Market Update. *CALSTART*: https://calstart.org/wp-content/uploads/2025/05/ZIO-ZET-June.pdf.
[10] U.S. Energy Information Administration. (2023). Annual Energy Outlook 2023: https://www.eia.gov/outlooks/archive/aeo23/.

The Reference case for AEO 2025 continues to include the IRA, as well as California's ACT program and the 2024 EPA vehicle rulemakings.[11] AEO 2025 also includes an alternative case, called the "Alternative Transportation case", in which California's ACT, the EPA's 2024 vehicle rulemakings, and NHTSA's 2024 final rule for CAFE standards for model years 2027-2032 are not in place. In addition, the AEO 2025 Alternative Transportation case also models a slower growth for IRA credit eligibility than the AEO 2025 Reference case.

In Figure 1, we compare the gasoline and diesel fuel prices for the three AEO scenarios:

- **AEO 2023 Reference case** used in the 2024 EPA vehicle rulemakings, which did not include California's ACT program or the rulemakings finalized by the EPA in 2024
- **AEO 2025 Reference case** that includes California's ACT program and the EPA's 2024 rulemakings
- **AEO 2025 Alt Transportation case** that removes the impacts of California's ACT program, the EPA's 2024 vehicle rulemakings, and NHTSA's 2024 CAFE rule, and lessens the growth of eligibility for IRA credits compared to the AEO 2025 Reference case

AEO 2023 prices are presented in 2022 dollars (2022$), and AEO 2025 prices are in 2024 dollars (2024$). The AEO 2025 prices shown in the chart below were converted to 2022$ by applying a multiplier of 0.942.[12]

[11] U.S. Energy Information Administration. (2025). Annual Energy Outlook 2025: https://www.eia.gov/outlooks/aeo/.

[12] U.S. Department of Congress, Bureau of Economic Analysis. (Last modified July 7, 2025). National GDP & Personal Income: https://www.bea.gov/itable/national-gdp-and-personal-income. See National Income and Product Accounts, Section 1 – Domestic Product and Income, Table 1.1.9. Implicit Price Deflators for Gross Domestic Product.

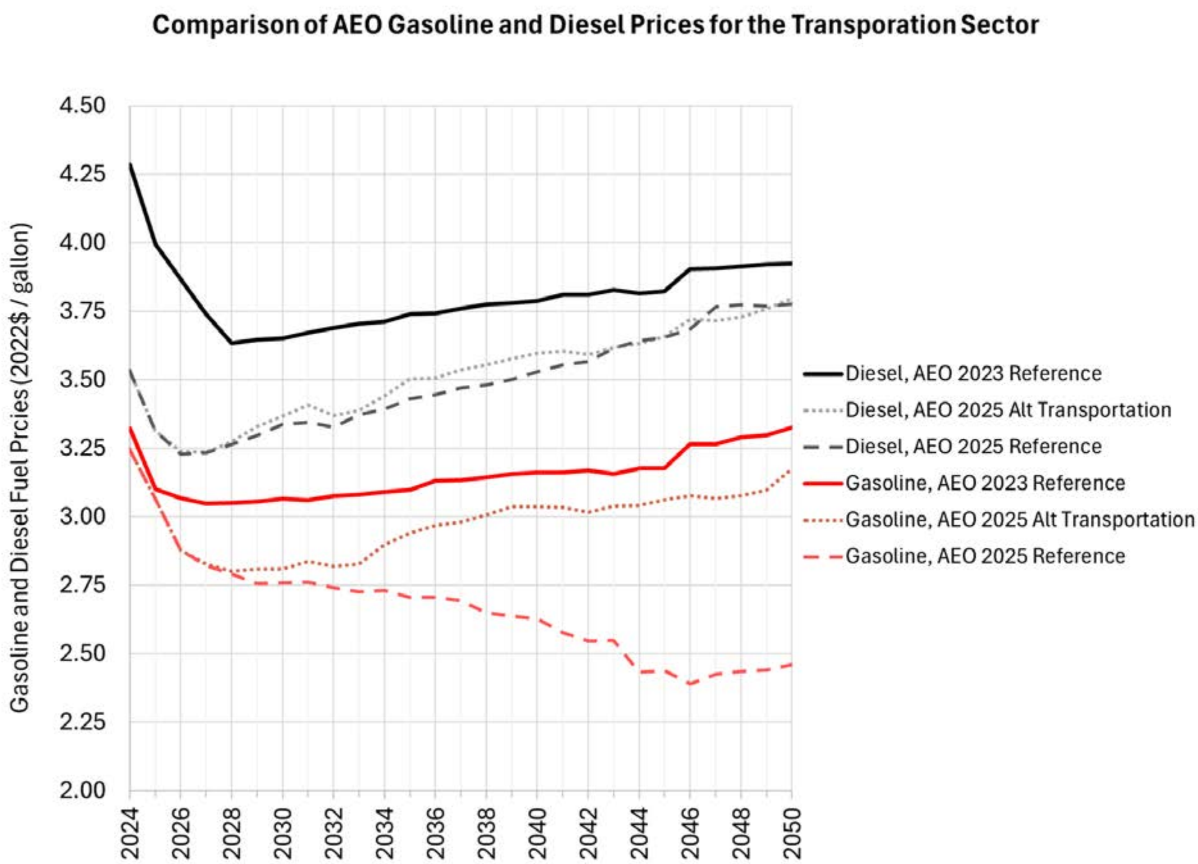


*Figure 1: Comparison of AEO 2023 and AEO 2025 Fuel Prices (2022$).*

<u>Summary of Gasoline Price Projections</u>

As shown in Figure 1, the AEO 2025 Reference price for gasoline fuel is significantly lower than AEO 2023, and the difference grows over time. In 2027, AEO 2025 Reference price is approximately $0.23/gallon lower than AEO 2023, and that difference grows to $0.49/gallon in 2038, and $0.87 in 2050. However, it does not appear that AEO 2025 took into account the policies being implemented by President Trump that are intended to drive down the price of gasoline and diesel.

For the AEO 2025 Alternative Transportation case, the difference compared to AEO 2023 is smaller, yet still lower than the prices in the AEO 2023, and the difference remains relatively stable over time. In 2027, the AEO 2025 Alternative Transportation price is $0.22/gallon lower than AEO 2023, and that difference shrinks to $0.14/gallon in 2038, and $0.15/gallon in 2050.

In general, the updated AEO 2025 projected gasoline fuel prices are lower than AEO 2023, which means for an individual vehicle owner, we would expect lower fuel savings from the purchase of a BEV compared to the savings projected by the EPA in its analysis for the 2024 vehicle rulemakings, all other things held equal.

<u>Summary of Diesel Price Projections</u>

As can be seen in Figure 1, the AEO 2025 Reference price for diesel fuel is lower than AEO 2023, and the difference shrinks over time. In 2027, AEO 2025 Reference diesel price is $0.51/gallon lower than AEO 2023, and that difference shrinks to $0.29/gallon in 2038, and $0.15/gallon in 2050.

The AEO 2025 Alternative Transportation case price projections for diesel fuel are similar to the AEO 2025 Reference case, though a little higher for most years. Therefore, the AEO 2025 Alternative Transportation case diesel price projections compared to AEO 2023 are also lower in each calendar year, though the difference is slightly smaller than the AEO 2025 Reference case. In 2027, the AEO 2025 Alternative Transportation case price is $0.50/gallon lower than AEO 2023, and that difference shrinks to $0.22/gallon in 2038, and $0.13 in 2050.

In general, the updated AEO 2025 projected diesel fuel prices are lower than AEO 2023. The lower AEO 2025 projected diesel fuel prices means that for an individual vehicle owner or operator, we would expect lower fuel savings from the purchase of a BEV compared to the EPA analysis performed for the 2024 vehicle rulemakings, all other things held equal. The lower projected diesel fuel prices in AEO 2025 for calendar years 2027 through 2055 would lengthen the payback periods for HD BEVs compared to the analysis done to support the HD GHG Phase 3 rule. A longer payback period could reduce the purchaser demand for EVs from the commercial vehicle sector.

For these reasons and others, we included a fuel price sensitivity assessment which examines the impact lower fuel prices have on some program costs and benefits. Specifically, we examine a $1.00/gallon lower gasoline cost and a $0.25/gallon lower diesel cost as compared to the AEO 2023 gasoline reference fuel cost. This assessment is summarized in chapter 6 of this document, with more details presented in Appendix A.3 and A.4.

# 4 Impact of EVs on the power generation sector and major changes since the 2024 vehicle rulemakings

Since the EPA issued the 2024 vehicle rulemakings, there have been two significant changes as they relate to the power generation sector. There has been a significant increase in the projected growth of electricity demand for artificial intelligence (AI) data centers, and the 2022 IRA solar and wind tax incentives have been repealed in OBBB.

The analysis used for the 2024 vehicle rulemakings included projections for all necessary increases in capacity and associated costs. These costs were included in the projected retail price of electricity, which included the costs of electricity generating unit (EGU) builds, EGU retrofits, EGU retirements, increased transmission capacity, and necessary upgrades to the distribution system to accommodate direct current (DC) fast charging for LD, MD, and HD plug-in EV (PEV) applications.[13] This was modeled utilizing the "EPA's Power Sector Modeling Platform Post-IRA 2022 Reference case using the Integrated Planing Model (IPM)." [14] IPM provides projections of least-cost capacity expansion, electricity dispatch, and emission control strategies for meeting energy demand and

[13] LMDV Regulatory Impact Analysis (RIA), Chapter 5: https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P1019VPM.pdf

[14] U.S. Environmental Protection Agency. (Last updated Mar. 19, 2025). Power Sector Post-IRA 2022 Reference Case: https://www.epa.gov/power-sector-modeling/post-ira-2022-reference-case.

environmental, transmission, dispatch, and reliability constraints represented within 67 regions of the 48 contiguous U.S. However, IPM does not account for difficulties in permitting for either EGUs or transmission lines.

The final LD and MD were anticipated to increase electricity generation by less than one percent in 2030, and by approximately 7.6 percent by 2050. When combined with anticipated demand from HD applications, electricity generation was anticipated to increase by 11.6 percent by 2050.[15]

The IPM analysis within the RIA for 2024 vehicle rulemakings estimated that higher levels of PEV adoption would result in an incremental increase in demand for electricity, which in turn resulted in improving economics for existing thermal resources such as coal-fired EGUs. This, in turn, resulted in fewer projected retirements at those facilities over the analysis period.[16] This analysis was predicated on demand data from AEO 2023, which in turn was calibrated to conditions as of 2022, and included full implementation of the IRA.

Electricity rates for the 2024 vehicle rulemakings were estimated from IPM results using the Retail Price Model.[17,18] The Retail Price Model showed a trend of reduced electricity rates through 2050 despite an increase in electricity demand through 2050. Increased costs due to increased generation and transmission capacity were more than offset by a shift towards renewables and increased grid battery storage from power sector tax incentives within the RIAs. The Retail Price Model projected higher national average electricity rates in 2050 due to the 2024 vehicle rulemakings of approximately 2.5% (approximately $0.0025 per kilowatt-hour (kWh)).

Since the 2024 vehicle rulemakings were finalized in the spring of 2024, there has been a significant change in the forecasts of electricity demand. According to the 2024 North American Electric Reliability Corporation (NERC) Long Term Reliability Assessment,[19] in 2022 the projected compound annual growth rate for summer peak demand over the ten-year period 2022-2031 was estimated to be 0.65%. In the latest available assessment, the ten-year compound annual growth rate for summer peak demand over the 2025-34 period is estimated to be 1.67%. This more than 2.5-fold increase in projected growth rates is driven primarily by increasing amounts of large commercial and industrial loads, particularly those related to data center demand for AI applications. These higher levels of demand significantly improve the market fundamentals of existing firm dispatchable capacity and reduce the likelihood of thermal resource retirement. Moreover, this demand growth significantly outweighs the level of incremental electricity demand from LD, MD, and HD PEV charging projected by the adoption of LMDV and HD GHG Phase 3 standards.

Furthermore, the passage of OBBB will also have important impacts on the power sector – notably, the phase-out of tax subsidies to wind and solar resources will likely reduce incremental builds of

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[15] LMDV RIA, https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P1019VPM.pdf.
[16] LMDV RIA, Chapter 5, https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P1019VPM.pdf.
[17] ICF. 2019. "Documentation of the Retail Price Model." ICF Contract Report to the U.S. EPA.
[18] LMDV RIA, Chapter 5, https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P1019VPM.pdf.
[19] North American Electric Reliability Corporation. (2024, updated July 15, 2025). December 2024 Long-Term Reliability Assessment:
https://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/NERC_Long%20Term%20Reliability%20Assessment_2024.pdf.

these technologies particularly after 2028. This, in turn, will further strengthen the relative economics of existing thermal resources, resulting in fewer retirements and therefore dampening the impact of LMDV and HD GHG Phase 3 on the power sector. Finally, higher levels of demand, particularly for around-the-clock power required for data centers, will likely further improve the outlook for thermal resources and reduce incentives for retirement. Collectively, these changes – including rescinding LD, MD, and HD GHG standards – would reflect a net improvement to energy and capacity markets for thermal resources. These changes may also be anticipated to impact the year-over-year reductions in the retail price of electricity forecast within the 2024 RIAs; however, the EPA did not perform the additional analysis that would be needed to determine the impacts on the retail price of electricity for this assessment for this proposal. The EPA expects to consider this further at the final rule stage.

Considering the need to meet this higher level of demand mainly driven by data centers, managing ongoing thermal retirements, and the need for additional transmission and resource development, NERC concludes that critical reliability challenges are facing the sector. No longer requiring compliance with LD, MD, and HD GHG standards would reduce the overall demand for electricity, which in turn may incrementally improve the reliability outlook for the sector. However, the impact of reducing demand from PEV charging is likely to be small in comparison to the impact from increased data center demand. For example, in 2030, PEV charging demand from all vehicle categories will be reduced by approximately 64 terawatt-hour (TWh)[20] compared to new demand from data centers of approximately 600 TWh.[21,22]

# 5 How do car and light truck buyers value improved fuel economy?

How potential buyers value improvements in the fuel economy of new cars and light trucks is an important issue in assessing the benefits and costs of government regulation. As noted in the Office of Management and Budget (OMB) Circular A-4 (2003),[23] "individual preferences of the affected population should be a guiding principle in the regulatory analysis." If buyers fully value the savings in fuel costs that result from higher fuel economy, manufacturers will presumably supply any improvements that buyers demand, and vehicle prices will fully reflect future fuel cost savings consumers would realize from owning—and potentially reselling—more fuel-efficient models.

If consumers internalize fuel savings in this case, more stringent fuel economy standards will impose net costs on vehicle owners and can only result in social benefits through correcting externalities, because consumers would already fully incorporate private savings into their

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[20] Sherwood, T. (2025). Vehicle Rule LD/MD/HD Physical Effects.
[21] U.S. Department of Energy (2025). Resource Adequacy Report Evaluating the Reliability and Security of the United States Electric Grid: https://www.energy.gov/sites/default/files/2025-07/DOE%20Final%20EO%20Report%20%28FINAL%20JULY%207%29.pdf.
[22] North American Electric Reliability Corporation. (Last updated July 2025). 2023 and 2024 NERC Electricity Supply & Demand database: https://www.nerc.com/pa/RAPA/ESD/pages/default.aspx.
[23] Office of Management and Budget. (2003). Circular A-4: Regulatory Analysis: https://obamawhitehouse.archives.gov/omb/circulars_a004_a-4.

purchase decisions, as discussed further below. If instead consumers systematically undervalue the cost savings generated by improvements in fuel economy when choosing among competing models due to some market failure such as an information asymmetry that leads to an underinvestment in fuel-saving technology, then more stringent fuel economy standards will lead manufacturers to adopt improvements in fuel economy that buyers might not choose despite the cost savings they offer and thus improve consumer welfare.

The potential for car buyers to voluntarily forego improvements in fuel economy that offer savings exceeding their initial costs is one example of what is often termed the "energy efficiency gap." The topic of the "energy efficiency gap" or "energy efficiency paradox" has been extensively discussed in previous analyses of vehicle GHG standards, including the 2024 LMDV final rule RIA. The appearance of such a gap, between the level of energy efficiency that would minimize consumers' overall expenses and what they actually purchase, is typically based on engineering calculations that compare the initial cost for providing higher energy efficiency to the discounted present value of the resulting savings in future energy costs.

There has long been an active debate about why such a gap might arise and whether it actually exists (Klemick and Wolverton, 2025).[24] Economic theory predicts that individuals will purchase more energy-efficient products only if the savings in future energy costs they offer promise to offset their higher initial costs. However, the additional up-front cost of a more energy-efficient product includes more than just the cost of the technology necessary to improve its efficiency; because consumers have a scarcity of resources, it also includes the opportunity cost of any other desirable features that consumers give up when they choose the more efficient alternative. In the context of vehicles, whether the expected fuel savings outweigh the opportunity cost of purchasing a vehicle offering higher fuel economy will depend, among other things, on how much its buyer expects to drive, their expectations about future fuel prices, the discount rate they use to value future expenses, the expected effect on resale value, and whether more efficient models offer equivalent attributes such as performance, carrying capacity, reliability, quality, or other characteristics.

Historically, the published literature has offered little consensus about consumers' willingness to pay for greater fuel economy, and whether it implies over-, under- or full-valuation of the expected discounted fuel savings from purchasing a model with higher fuel economy. Most studies have relied on car buyers' purchasing behavior to estimate their willingness to pay for future fuel savings. Traditionally the approach was to use "discrete choice" models that relate cross-sectional data on individual buyers' choices among competing vehicles to their purchase prices, fuel economy, and other attributes (such as performance, carrying capacity, and reliability), and to infer buyers' valuation of higher fuel economy from the relative importance of purchase prices and fuel economy.[25] Empirical estimates using this approach span a wide range, extending from substantial undervaluation of fuel savings to significant overvaluation, thus making it difficult to draw solid conclusions about the influence of fuel economy on vehicle buyers' choices (e.g., Helfand and

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[24] Klemick, H., and Wolverton, A. (2025). The Energy-Efficiency Gap in Encyclopedia of Energy, Natural Resource, and Environmental Economics. 2nd Edition. *Elsevier Academic Press*: https://doi.org/10.1016/B978-0-323-91013-2.00033-2

[25] In a typical vehicle choice model, the ratio of estimated coefficients on fuel economy—or more commonly, fuel cost per mile driven—and purchase price is used to infer the dollar value buyers attach to slightly higher fuel economy.

Wolverton, 2011 and Greene, 2010).[26,27] Because a vehicle's price is often correlated with its other attributes (both measured and unobserved), analysts have often used instrumental variables or other approaches to address endogeneity and other resulting concerns (e.g., Berry et al., 1995).[28]

More recent research has criticized these cross-sectional studies; some have questioned the effectiveness of the instruments they use (Allcott and Greenstone, 2012)[29], while others have observed that coefficients estimated using non-linear statistical methods can be sensitive to the optimization algorithm and starting values (Knittel and Metaxoglou, 2014)[30]. Collinearity (i.e., high correlations) among vehicle attributes—most notably among fuel economy, performance or power, and vehicle size—and between vehicles' measured and unobserved features also raises questions about the reliability and interpretation of coefficients that may conflate the value of fuel economy with other attributes (Leard et al., 2023; [31] Sallee et al., [32] 2016; Busse et al., 2013;[33] Allcott and Wozny, 2014;[34] Allcott and Greenstone, 2012; Helfand and Wolverton, 2011).

In an effort to overcome shortcomings of past analyses, more recent studies have relied on panel data from sales of individual vehicle models to improve their reliability in identifying the association between vehicles' prices and their fuel economy (Leard et al., 2023; Sallee et al., 2016; Allcott and Wozny, 2014; Busse et al., 2013). Although they differ in certain details, each of these analyses relates changes over time in individual models' selling prices to fluctuations in fuel prices, differences in their fuel economy, and increases in their age and accumulated use, which affects their expected remaining life and thus their market value. Because a vehicle's future fuel costs are a function of both its fuel economy and expected gasoline prices, changes in fuel prices have different effects on the market values of vehicles with different fuel economy; comparing these effects over time and among vehicle models reveals the fraction of changes in fuel costs that is reflected in changes in their selling prices (Allcott and Wozny, 2014). Using very large samples of sales enables these studies to define vehicle models at an extremely disaggregated level, which enables their authors to isolate differences in their fuel economy from the many other attributes, including those that are difficult to observe or measure, that affect their sale prices.[35] These studies

[26] Helfand, G., and Wolverton, A. (2011). Evaluating the Consumer Response to Fuel economy: A Review of the Literature. *International Review of Environmental and Resource Economics,* 5: 103-146.
[27] Greene, D. (2010). How Consumers Value Fuel Economy: A Literature Review. EPA-420-R-10-008.
[28] Berry, S. et al.. (1995). Automobile Prices in Market Equilibrium. *Econometrica,* 63(4): 841-890.
[29] Allcott, H., and Greenstone, M. (2012). Is There an Energy Efficiency Gap*? Journal of Economic Perspectives,* 26(1): 3-28.
[30] Knittel, C., and Metaxoglou, K. (2014). Estimation of Random-Coefficient Demand Models: two Empiricists' Perspectives. *Review of Economics and Statistics,* 96(1): 34-59.
[31] Leard, B. et al.. (2023). How Much Do Consumers Value Fuel Economy and Performance? Evidence from Technology Adoption. *Review of Economics and Statistics,* 105(1): 158–174.
[32] Sallee, J. et al..( 2016). Do Consumers Recognize the Value of Fuel Economy? Evidence from Used Car Prices and Gasoline Price Fluctuations. *Journal of Public Economics,* 135: 61-73.
[33] Busse, M. R. et al.. (2013). Are Consumers Myopic? Evidence from New and Used Car Purchases. *American Economic Review*, 103(1): 220– 256.
[34] Allcott, H., and Wozny, N. (2014). Gasoline Prices, Fuel Economy, and the Energy Paradox. *Review of Economics and Statistics,* 96(5): 779– 795.
[35] These studies rely on individual vehicle transaction data from dealer sales and wholesale auctions, which include actual sale prices and allow their authors to define vehicle models at a highly disaggregated level. For

point to a somewhat narrower range of estimates than suggested by previous cross-sectional studies; more importantly, ***they consistently suggest that buyers value a large proportion—and perhaps even all—of the future savings that models with higher fuel economy offer***.[36]

Because they rely on estimates of fuel costs over vehicles' expected remaining lifetimes, these studies' estimates of how buyers value fuel economy are sensitive to the strategies they use to isolate differences among individual models' fuel economy, as well as to their assumptions about buyers' discount rates and gasoline price expectations, among others. Since Anderson et al. (2013)[37] found evidence that consumers expect future gasoline prices to resemble current prices, the EPA uses this assumption to compare the findings of the three studies and examine how their findings vary with the discount rates buyers apply to future fuel savings.[38]

As Table 1 indicates, for discount rates of five to six percent, the Busse et al. (2013) results imply that vehicle prices reflect 60 to 100 percent of future fuel costs. Allcott and Wozny (2014) found that consumers incorporate 55 percent of future fuel costs into vehicle purchase decisions at a six percent discount rate, when their expectations for future gasoline prices are assumed to reflect prevailing prices at the time of their purchases. With the same expectation about future fuel prices, the authors report that consumers would fully value fuel costs only if they apply discount rates of 24 percent or higher. However, these authors' estimates are closer to full valuation when using

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instance, Allcott and Wozny (2014) differentiate vehicles by manufacturer, model or nameplate, trim level, body type, fuel economy, engine displacement, number of cylinders, and "generation" (a group of successive model years during which a model's design remains largely unchanged). All three studies include transactions only through mid-2008 to limit the effect of the recession on vehicle prices. To ensure that the vehicle choice set consists of true substitutes, Allcott and Wozny (2014) define the choice set as all gasoline-fueled light-duty cars, trucks, SUVs, and minivans that are less than 25 years old (i.e., they exclude vehicles where the substitution elasticity is expected to be small). Sallee et al. (2016) exclude diesels, hybrids, and used vehicles with less than 10,000 or more than 100,000 miles.

[36] Killian and Sims (2006) and Sawhill (2008) rely on similar longitudinal approaches to examine consumer valuation of fuel economy except that they use average values or list prices instead of actual transaction prices. Since these studies remain unpublished, their empirical results are subject to change, and they are excluded from this discussion.

[37] Anderson, S.T. et al.. (2013). What do consumers believe about future gasoline prices? *Journal of Environmental Economics and Management,* 66(3): 383-403.

[38] Each of the studies makes slightly different assumptions about appropriate discount rates. Sallee et al. (2016) use five percent in their base specification, while Allcott and Wozny (2014) rely on six percent. As some authors note, a five to six percent discount rate is generally consistent with observed interest rates on car loans, but they also acknowledge that borrowing rates could be higher in some cases, which could be used to justify higher discount rates. Rather than assuming a specific discount rate, Busse et al. (2013) and Leard et al. (2023) directly estimate implicit discount rates at which future fuel costs would be fully internalized; Busse et al. (2013) find discount rates of six to 21 percent for used cars and one to 13 percent for new cars at assumed demand elasticities ranging from -2 to -3. Leard et al. (2023) finds implied discount rates of 10 and 12 percent using an assumed demand elasticity of -2 and -3, respectively. Their estimates can be translated into the percent of fuel costs internalized by consumers, assuming a particular discount rate. To make the Busse et al. (2013) results more directly comparable to the other studies, we assume a range of discount rates and uses the authors' spreadsheet tool to translate their results into the percent of fuel costs internalized into the purchase price at each rate. Because Busse et al. (2013) estimate the effects of future fuel costs on vehicle prices separately by fuel economy quartile, these results depend on which quartiles of the fuel economy distribution are compared; our summary shows results using the full range of quartile comparisons.

gasoline price forecasts that mirror oil futures markets, because the petroleum market expected prices to fall during this period (this outlook reduces the discounted value of a vehicle's expected remaining lifetime fuel costs). With this expectation, Allcott and Wozny (2014) found that buyers value 76 percent of future cost savings (discounted at six percent) from choosing a model that offers higher fuel economy, and that a discount rate of 15 percent would imply that they fully value future cost savings. Sallee et al. (2016) begins with the perspective that buyers fully internalize future fuel costs into vehicles' purchase prices and cannot reliably reject that hypothesis; their base specification suggests that changes in vehicle prices incorporate slightly more than 100 percent of changes in future fuel costs. Leard et al.'s (2023) preferred estimate implies that consumers only internalize 55 percent of changes in future fuel costs when assuming a real discount rate of 1.3 percent and that fuel prices will follow a random walk (i.e., current prices are a prediction of future prices). When they adopt similar assumptions to Busse et al. (2013) for vehicle miles traveled (VMT) and scrappage rates, they find that consumers valued 73 percent of future fuel costs. As Table 1 suggests, higher private discount rates move all the estimates closer to full valuation or to over-valuation, while lower discount rates imply less complete valuation in all four studies.

*Table 1: Percent of Future Fuels Costs Internalized in Car and Light-Truck Purchase Prices*

| **Authors (Pub. Date)** | **Future fuel price assumption** | **Vehicles Type** | **Discount rate assumption** | | | |
|---|---|---|---|---|---|---|
| | | | **1 - 3%** | **5%** | **6% -7%** | **10%** |
| Busse et al. (2013) | Gasoline price at time of sale | New and used cars & light trucks | 54-87% | 60-96% | 62-100% | 73-117% |
| | 24-month gasoline price futures | | 71-103% | 78-114% | 81-119% | 96-139% |
| Allcott & Wozny (2014) | Gasoline price at time of sale | Used cars & light trucks | 48% | | 55% | 65% |
| | Oil futures-based forecast | | 67% | | 76% | 87% |
| Sallee et al. (2016) | Gasoline price at time of sale | Used cars & light trucks | | 101% | | 142% |
| Leard et al (2023) | Gasoline price at time of sale | New cars & light trucks | 54-73% | 69% | 77% | |
| | AEO projected gasoline price | | 57% | | | |

*Note: The ranges in the Busse et al. (2013) estimates depend on which quartiles of the fuel economy distribution are compared. With no prior on which quartile comparison to use, this analysis presents the full quartile comparison range.

The studies also explore the sensitivity of the results to other parameters that could influence their results. Busse et al. (2013) and Allcott and Wozny (2014) find that relying on data that suggest lower annual vehicle use or survival probabilities, which imply that vehicles will not last as long, moves their estimates closer to full valuation, an unsurprising result because both reduce the changes in expected future fuel costs caused by fuel price fluctuations. Allcott and Wozny's (2014) base results rely on an instrumental variables estimator that groups miles per gallon (MPG) into two quantiles to mitigate potential attenuation bias due to measurement error in fuel economy, but they find that greater disaggregation of the MPG groups implies greater undervaluation (for example, it reduces the 55 percent estimated reported in Table 1 to 49 percent). Busse et al. (2013) allow gasoline prices to vary across local markets in their main specification; using national average gasoline prices, an approach more directly comparable to the other studies, results in estimates that are closer to or above full valuation. Sallee et al. (2016) find modest undervaluation by vehicle fleet operators or manufacturers making large-scale purchases, compared to retail dealer sales (i.e., 70 to 86 percent).

Only Busse et al. (2013) and Leard et al. (2023) examine new vehicle sales; Busse et al (2013) find that consumers value between 75 to 129 percent of future fuel costs for new vehicles, while Leard et al. (2023) find they value between 54 and 77 percent, depending on the discount rate assumed. Allcott and Wozny (2014) 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 higher fraction of future fuel costs: 93 percent for one- to three-year-old vehicles, compared to 76 percent for all used vehicles assuming the same price expectation.[39] Allcott and Wozny (2014) and Sallee et al. (2016) also find that future fuel costs for older vehicles are substantially undervalued (26-30 percent).

The empirical literature finds evidence that manufacturers invest in performance instead of improved fuel economy when standards remain unchanged (Leard et al., 2023; Klier and Linn, 2016;[40] Knittel, 2011[41]). Thus, in addition to understanding how consumers value changes in fuel economy, it is important to account for the value they place on changes in performance at the margin. Explicitly accounting for the tradeoff between fuel economy and performance, Leard et al. (2023) find that consumers are willing to pay about three times as much for improved performance than a comparable fuel economy increase. Taken together, they calculate that a one percent

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[39] The pattern of results in Allcott and Wozny (2014) for different vehicle ages is similar when they use retail transaction prices (adjusted for customer cash rebates and trade-in values) instead of wholesale auction prices, although the degree of valuation falls substantially in all age cohorts with the smaller, retail price based sample.

[40] Klier, T., and Linn, J. (2016). Technological Change, Vehicle Characteristics and the Opportunity Costs of Fuel Economy Standards. *Journal of Public Economics,* 133: 41–63.

[41] Knittel, C. (2011). Automobiles on Steroids: Product Attribute Tradeoffs and Technological Progress in the Automobile Sector. *American Economic Review*, 101: 368–3399.

improvement in fuel economy slightly reduces consumer welfare, holding all other vehicle attributes constant, despite undervaluation of fuel economy.[42,43,44,45]

Some commenters on previous rules have taken issue with the EPA's characterization of the literature on the value of fuel economy, citing the Agency's previous determination that the estimates in the literature represented too large a range, and the degree of uncertainty made including a value of fuel economy challenging, while other commenters have agreed with the EPA's characterization. But what analysts assume about consumers' vehicle purchasing behavior, particularly about potential buyers' perspectives on the value of increased fuel economy, clearly matters in the context of benefit-cost analysis for any regulation that affects fuel economy. Considering the recent evidence on this question, a more nuanced approach than merely assuming that buyers drastically undervalue benefits from higher fuel economy, (and that, as a consequence, these benefits are unlikely to be realized without stringent fuel economy standards) seems warranted.

Empirical results that find consumers internalize 100 percent of changes in future fuel costs means that consumers are already fully incorporating private fuel savings into their purchase decisions. Under this case, a finding based on engineering calculations that the initial cost of requiring higher energy efficiency is less than the discounted present value of future energy cost savings is suggestive of missing or misspecified costs or consumer preferences in the analysis. Use of that framework to project purchase decisions would then be likely to provide results inconsistent with expectations about real world outcomes.

One approach to addressing such gaps is to incorporate additional or refined aspects of the tradeoffs being considered by consumers and/or improved reflections of their preferences into the calculations. However, many of these aspects are not directly observable and can be challenging to robustly represent and parameterize in a model. An alternative approach is to adjust the value consumers place on the private fuel savings in the modeling such that projected purchase decisions match available evidence and expectations. Under this approach, the value of private fuel savings considered by consumers in the modeling reflects their willingness to pay for the increase in energy efficiency adjusted for potentially missing costs or consumer preferences.

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[42] Allcott, H. and Knittel, C. (2019). Are Consumers Poorly Informed about Fuel Economy? Evidence from Two Experiments. *American Economic Journal: Economic Policy,* 11(1): 1 – 37.

[43] This finding is consistent with other recent work by Allcott and Knittel (2019). They find that experiments designed to overcome possible consumer inattention and imperfect information in new car buyers result in little additional uptake of fuel economy. They conclude that one must either point to some other market or behavioral failure to justify increasingly stringent fuel economy standards or that the large net private benefits projected by recent regulatory analyses do not exist. "The latter possibility would arise if the [regulatory analyses] engineering models did not account for the full fixed costs, production costs, or performance reductions from fuel economy-improving technologies."

[44] Watten, A., and Anderson, S. (2025). Attribute Production and Biased Technical Change in Automobiles. *National Bureau of Economic Research* Working Paper, #33979: https://www.nber.org/system/files/working_papers/w33979/w33979.pdf .

[45] Recent, still unpublished work by Watten and Anderson (2025) finds that the tradeoff between fuel economy and performance may have fallen over time.

Manufacturers have consistently told the Agency that new vehicle buyers will pay for about two or three years' worth of fuel savings before the price increase associated with providing those improvements begins to affect sales. In public comments on the Safer Affordable Fuel-Efficient Vehicle Rule proposed by NHTSA and the EPA in 2018 (SAFE rule),[46] the National Automobile Dealers Association (NADA), the Alliance of Automobile Manufacturers (Alliance), and American Fuel and Petrochemical Manufacturers (AFPM) argued that CAFE/carbon dioxide ($CO_2$) standards have already reached the point where the price increases necessary to recoup manufacturers' increased costs for providing further increases in fuel economy outweigh the value of fuel savings, and requiring further increases in fuel economy will reduce new vehicle sales.[47] The modeling conducted for the scenarios in Appendix A assumes that the value consumers are willing to pay for fuel economy improvements is equal to  the savings from the first 2.5 years of reduced fuel costs in all components of the analysis that reflect consumer decisions regarding LD and MD vehicle purchases and retirements.[48] More specifically, this analysis explicitly assumes that: 1) consumers are willing to pay for fuel economy improvements that pay back within the first 2.5 years of vehicle ownership (at average usage rates); 2) manufacturers know this and will provide these improvements even in the absence of regulatory pressure; 3) consumers weigh these savings against increases in new vehicle prices when deciding whether to purchase a vehicle; 4) vehicle performance is held constant (i.e., the potential to enhance performance even further in lieu of investing in fuel economy is not accounted for);[49] and 5) the amount of technology for which buyers will pay fluctuates with fluctuating fuel prices.

One interpretation of these specifications, and in particular the assumption that consumers only value 2.5 years of fuel savings, is that consumers significantly undervalue the private fuel savings in their purchase decisions. In which case, some of the additional fuel savings beyond the 2.5 years should be incorporated into the benefit cost analysis. However, based on evidence from recent studies that use a rich panel of individual transaction data, several of these assumptions, or that interpretation, seem implausible. Another interpretation is that consumers fully internalize changes in future fuel costs and the value of 2.5 years of fuel savings approximates consumers' willingness to pay for the increase in fuel economy adjusted for potentially missing costs or consumer preferences. In which case, the benefit cost analysis should focus on that estimate of willingness to pay for changes in fuel savings.

# 6 Summary of results

As discussed in the introduction, there have been many changes to the underlying assumptions used for the 2024 rulemakings. These changes impact all aspects of the 2024 RIAs and thus the EPA cannot rely upon those previous assessments to confidently and appropriately quantify or

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[46] 83 FR 42986; Aug. 24, 2018.
[47] *See* NADA, NHTSA-2018-0067-12064 at 11; Auto Alliance, Full Comment Set, NHTSA-2018-0067-12073 at 163-64; AMFP, Comments, NHTSA-2018-0067-12078-29 at 3.
[48] When accounting for social benefits and costs associated with an alternative, the full lifetime value of fuel savings is included.
[49] Recent, still unpublished work by Watten and Anderson (2025) notes that holding vehicle attributes fixed may overstate technology costs since they find evidence that downsizing is a much cheaper alternative to a technology-only response to meeting abatement requirements.

monetize many of the impacts from this proposed action. Reflecting these uncertainties, the EPA has estimated the impacts of removing the GHG standards from LD, MD, and HD vehicles and HD engines using two different modeling methodologies, resulting in seven different modeled scenarios. The details for the first method (and scenarios one through five) are presented in Appendix A. The details for the second method (and scenarios six and seven) are presented in Appendix B.

The first method uses the same models and tools used to estimate the regulatory impacts presented in the 2024 RIAs. For this proposal, we estimate impacts under five different scenarios using these tools. The first scenario contains all the same assumptions and inputs as presented in the 2024 RIAs. The second scenario estimates the impacts of removing the IRA and the ACT rule. Recognizing the significant uncertainties related to future gasoline and diesel prices, the third scenario considers lower fuel prices, in addition to the removal of IRA and the ACT rule. All other assumptions and inputs are the same as those used in the 2024 RIAs. The fourth and fifth scenarios build on the second and third scenarios, respectively, accounting for only the first 2.5years of fuel savings in estimating the net monetized impact of this proposed rule.

The first scenario shows the impacts of rescinding the GHG standards for LD, MD, and HD vehicles result in an estimated net cost of about $260 billion over 2027 through 2055 discounted at a 3 percent discount rate, or $26 billion discounted at a 7 percent discount rate. This is associated with an annualized value of about $13 billion per year or $2.1 billion dollars per year, respectively.

Removing IRA tax credits and the ACT rule result in higher estimated net societal costs associated with rescinding GHG standards for LD, MD, and HD vehicles compared to when the policies are in place. The estimated net costs under this second scenario are about $350 billion over 2027 through 2055 at a three percent discount rate, or $52 billion discounted at a 7 percent rate. These are associated with annualized values of about $18 billion per year and $4.1 billion per year, respectively. This change is largely driven by higher fuel consumption and associated fuel costs, which is greater than the reduction in vehicle technology costs. Both increased fuel consumption and technology costs are consistent with the expected impact of the removal of IRA credits and the ACT program. Removing both of these impacts led to reduced penetration of BEVs in the action case (i.e., without any GHG standards), while having relatively little impact on BEV penetration in the no action case (i.e., where BEV adoption is driven by Federal GHG standards). However, it is important to note that these results should be considered with some question, given the potential change in future product offerings, including the potential restriction or elimination of sales of higher GHG emitting gasoline and diesel vehicles, which firms may need to do to ensure compliance with the vehicle GHG standards in the absence of the significant incentives included in the 2022 IRA – effects which we have not captured in our modeling assessment. Specifically, as discussed in more detail in Appendix A, the EPA's modeling of the LD vehicle market showed the industry was not able to comply with the MY 2032 $CO_2$ standard in the absence of IRA credits. In addition, as discussed in more detail in Appendix A, for the HD vehicle sector, the EPA's model would not project compliance with the MY 2027 and later $CO_2$ standards in the absence of IRA credits.

As discussed in Chapter 3, it is likely that diesel and gasoline prices will be lower throughout the analysis period compared to the fuel prices used in the 2024 RIAs. The third scenario builds on the assumptions in the second scenario and estimates the effects of reducing the AEO 2023 fuel price projections by $0.25 per gallon for diesel and $1.00 per gallon for gasoline. With these lower fuel prices, we estimate a reduction in the net societal costs (i.e., a net benefit) associated with rescinding GHG standards of about $160 billion over 2027 through 2055 at a three percent discount rate, or $18 billion at a seven percent discount rate. These are associated with a decrease in net societal costs of about $9 billion per year or $18 billion per year, respectively. In contrast to the second scenario, results of this scenario are driven primarily by the reduction in vehicle technology costs, which are now only partially offset by the lower increase in fuel costs associated with greater fuel consumption.

As discussed in Chapter 5, there is uncertainty regarding how vehicle purchasers value the fuel savings that result from increased fuel efficiency. To reflect some of this uncertainty, the fourth and fifth scenarios discussed in Appendix A.4 assume consumers' willingness to pay for the changes in fuel economy are consistent with the value of the first 2.5 years of fuel savings in estimating the net monetized impacts of this proposed rule. Both the fourth and the fifth scenarios are estimated assuming no IRA tax credits or ACT rule. The fourth scenario assumes the 2023 AEO prices, as in the second scenario, while the fifth scenario assumes the reduced fuel prices used in the third scenario. The estimates for the fourth scenario result in a reduction in the net societal costs (i.e., a net benefit) associated with rescinding GHG standards of about $380 billion over 2027 through 2055 at a three percent discount rate, or $320 billion at a seven percent discount rate. These are associated with a decrease in net societal costs of about $20 billion per year or $26 billion per year, respectively. The estimates for the fifth scenario result in a reduction in net societal costs of about $490 billion over 2027 through 2055 at a 3 percent discount rate, or $380 billion at a 7 percent discount rate. These are associated with a decrease in net societal costs of about $26 billion per year or $31 billion per year, respectively.

Table 2 and Table 3 show the net present value of the monetized savings, costs, and net savings of the five scenarios discussed above presented at seven and three percent discount rates, respectively.

*Table 2: Monetized Savings, Costs, and Net Savings at 7 Percent Net Present Value (billions of 2022 dollars)**

| | **2024 LMDV and HDP3 Rule Analysis** | **2024 LMDV and HDP3 Rule Analysis, no IRA and ACT** | **2024 LMDV and HDP3 Rule, no IRA and ACT; low liquid fuel prices** | **2024 LMDV and HDP3 Rule Analysis, no IRA and ACT, 2.5 years of fuel savings** | **2024 LMDV and HDP3 Rule; no IRA and ACT, low liquid fuel prices, 2.5 years of fuel savings** |
|---|---|---|---|---|---|
| **Savings** | $570 | $640 | $640 | $640 | $640 |
| **Costs** | $590 | $690 | $420 | $320 | $260 |
| **Net Savings** | ($30) | ($50) | $220 | $320 | $380 |

*Results may not sum due to rounding.

*Table 3: Monetized Savings, Costs, and Net Savings at 3 Percent Net Present Value (billions of 2022 dollars)**

| | 2024 LMDV and HDP3 Rule Analysis | 2024 LMDV and HDP3 Rule Analysis, no IRA and ACT | 2024 LMDV and HDP3 Rule, no IRA and ACT; low liquid fuel prices | 2024 LMDV and HDP3 Rule Analysis; no IRA and ACT, 2.5 years of fuel savings | 2024 LMDV and HDP3 Rule; no IRA and ACT, low liquid fuel prices, 2.5 years of fuel savings |
|---|---|---|---|---|---|
| **Savings** | $950 | $1,030 | $1,030 | $1,030 | $1,030 |
| **Costs** | $1,210 | $1,390 | $870 | $660 | $550 |
| **Net Savings** | ($260) | ($350) | $160 | $380 | $490 |

*Results may not sum due to rounding.

The second method uses a revealed preference approach to project program savings, costs, and net savings under two additional scenarios. The results under both three and seven percent discount rates are presented in Table 4.

The sixth scenario utilizes vehicle compliance cost values extrapolated from earlier EPA actions. This scenario results in an estimated reduction in the net societal costs (i.e., a net benefit) associated with rescinding GHG standards of about $3,050 billion over 2027 through 2055 at a three percent discount rate, or $1,720 billion at a seven percent discount rate. These are associated with a decrease in net societal costs of about $160 billion per year or $150 billion per year, respectively.

The seventh scenario utilizes market information to project vehicle compliance costs. This scenario results in an estimated reduction in the net societal costs *(i.e.*, a net benefit) associated with rescinding GHG standards of about $8,180 billion over 2027 through 2055 at a three percent discount rate, or $4,660 billion at a seven percent discount rate. These are associated with a decrease in net societal costs of about $440 billion per year or $400 billion per year, respectively. Details on the revealed preference approach and scenarios six and seven are provided in Appendix B.

*Table 4: Revealed Preference Method: Monetized Savings, Costs, and Net Savings (billions of dollars)**

| | EPA cost extrapolation, 3% DR | Market Data, 3% DR | EPA cost extrapolation, 7% DR | Market Data, 7% DR |
|---|---|---|---|---|
| **Savings, annualized** | $170 | $440 | $160 | $410 |
| **Costs, annualized** | $8 | $5 | $7 | $5 |
| **Net Savings, annualized** | $160 | $440 | $150 | $400 |
| **Net Savings, NPV** | $3,050 | $8,180 | $1,720 | $4,660 |

*Results may not sum due to rounding.

# 7 Small Business Analysis

The Regulatory Flexibility Act (RFA), as amended by the Small Business Regulatory Enforcement Fairness Act of 1996 (SBREFA), generally requires an agency to prepare a regulatory flexibility analysis for any rule subject to notice-and-comment rulemaking requirements under the Administrative Procedure Act or any other statute. This requirement does not apply if the agency certifies that the rule will not have a significant economic impact on a substantial number of small entities. This chapter contains an overview of small entities in the LD, MD, and HD vehicle and HD engine markets, and our assessment that the proposed rule would not have a significant impact on a substantial number of small entities.

Under the Regulatory Flexibility Act (5 USC 601 et seq.), a small entity is defined as: (1) a business that meets the definition for small business based on the Small Business Administration's (SBA) size standards; (2) a small governmental jurisdiction that is a government of a city, county, town, school district, or special district with a population of less than 50,000; or (3) a small organization that is any not-for-profit enterprise which is independently owned and operated and is not dominant in its field.

This analysis considers small business entities that are subject to the LD, MD, and HD GHG emission standards and related regulations we propose to remove. Small governmental jurisdictions and small not-for-profit organizations would not be subject to the proposed rule as they have no certification or compliance requirements.

The regulated entities that are subject to the regulations we are proposing to remove in this proposed rule are engine and vehicle manufacturers, alternative fuel converters, and independent commercial importers subject to GHG emissions standards for vehicles. These entities are expected to have registered under NAICS codes shown in Table 5. The small business size standards that qualify the regulated entities as "small entities" are also outlined in Table 5.

*Table 5: Primary small business NAICS categories affected by this proposed rule[a]*

| NAICS Code[b] | NAICS Title | Defined by SBA (3/17/2023) as a small business if less than or equal to:[c] |
|---|---|---|
| 336110 | Automobile and Light-duty Motor Vehicle Manufacturing | 1,500 employees |
| 336120 | Heavy Duty Truck Manufacturing | 1,500 employees |
| 336211 | Motor Vehicle Body Manufacturing | 1,000 employees |
| 336213 | Motor Home Manufacturing | 1,250 employees |
| 336310 | Motor Vehicle Gasoline Engine and Engine Parts Manufacturing | 1,050 employees |
| 336390 | Other Motor Vehicle Parts Manufacturing | 1,000 employees |
| 333618 | Other Engine Equipment Manufacturing | 1,500 employees |
| 423110 | Automobile and Other Motor Vehicle Merchant Wholesalers | 250 employees |
| 811198 | All Other Automotive Repair and Maintenance | $10.0 million annual receipts |

[a] According to SBA's regulations (13 CFR Part 121), businesses with no more than the listed number of employees or dollars in annual receipts are considered "small entities" for RFA purposes.
[b] NAICS Association. NAICS & SIC Identification Tools: *https://www.naics.com/search*.
[c] U.S. Small Business Administration. (2023). Table of Small Business Size Standards Matched to North American Industry Classification System Codes: https://www.sba.gov/document/support-table-size-standards; pdf version at https://www.sba.gov/sites/default/files/2023-06/Table%20of%20Size%20Standards_Effective%20March%2017%2C%202023%20%282%29.pdf.

All entities, including all small entities, in the three industries (engine and vehicle manufacturers, alternative fuel converters, and commercial importers) are expected to see a decrease in regulatory burden as a result of the proposed action. This action proposes to remove portions of the regulations of the standard-setting parts directly related to GHG emission standards and compliance provisions for implementing the EPA's GHG engine and vehicle programs. We do not anticipate that there would be any significant adverse economic impact on directly regulated small entities as a result of these revisions. Because the proposed action would relieve regulatory burden, creating a benefit for the small entities subject to the current rules, an initial regulatory flexibility analysis of this rule is not required.

An additional benefit of the proposed rule would be to give vehicle buyers, including vehicle buyers that are small entities, more choices and relieve them from unnecessary and sometimes prohibitive regulatory costs that would be built into vehicle prices without this action. This action proposes to achieve this end by removing portions of the regulations of the standard-setting parts directly related to GHG emission standards and compliance provisions that apply to engine and vehicle manufacturers, alternative fuel converters, and independent commercial importers implementing the EPA's GHG engine and vehicle programs. The EPA notes that about 14 million Schedule C businesses own at least one vehicle, with most of those owning two or more. With 285 million vehicles registered nationwide, about 10 percent of those vehicles, if not more, are owned by small businesses. Additional vehicles are owned by non-profits and small for-profit businesses that do not file Schedule C. If finalized, the savings to these businesses would be substantial, as discussed in Section 6 of this DRIA.

# Appendix A: Results using LMDV and HDP3 methodologies

The analyses in this Appendix rely on the same models and tools used to analyze the impacts of the LMDV and HD GHG Phase 3 rules as discussed in the final RIAs for those rules. The assumptions and methodologies can be found in those previously docketed RIAs. We recognize that by using the impact estimates from the prior rules, this analysis does not account for the fact that standards for non-GHGs finalized in the LMDV rule (such as particulate matter ($PM_{2.5}$) and non-methane organic gases plus nitrogen oxides ($NMOG+NO_X$) standards) will remain in place.

## Appendix A.1: Results using 2024 LMDV and HDP3 methods and assumptions

The results presented in Table A- 1 are estimated using the same assumptions, methods and tools as used in the analyses for the LMDV and HDP GHG Phase 3 rules, including projections of vehicles, technologies, emission estimates, and fuel prices. These results also include the continued existence IRA tax credits and the California ACT rule as assumed in the rules finalized in 2024.

*Table A- 1: Net monetized impacts of the proposal based on 2024 RIA analyses, including IRA tax credits and the CA ACT rule (billions of 2022 dollars)**

| | 2055 | Present Value at 3% | Present Value at 7% | Annualized Value at 3% | Annualized Value at 7% |
|---|---|---|---|---|---|
| Vehicle Technology | $38 | $750 | $450 | $39 | $37 |
| Electric Vehicle Supply Equipment & Replacements | $11 | $200 | $120 | $11 | $9.5 |
| Fuel, Repair, Maintenance, Insurance, etc. | ($140) | ($1,100) | ($560) | ($60) | ($45) |
| Energy Security, Refueling Time, & Drive Value | ($7.8) | ($70) | ($35) | ($3.7) | ($2.8) |
| Net Monetized Impacts | ($100) | ($260) | ($26) | ($13) | ($2.1) |

* Positive values reflect savings due to the proposal (i.e., decreases in social costs) while negative values reflect increases in social costs.

For additional information on the development of these values, please see the RIAs developed for the 2024 LMDV and HDP3 final rules.[50]

## Appendix A.2: Results from removing IRA tax credits and CA ACT rule

The results in Table A- 2 illustrate the estimated impact of rescinding GHG standards when the IRA tax credits and California ACT program are removed. All other assumptions and inputs remain the

[50] See "Multi-Pollutant Emissions Standards for Model Years 2027 and Later Light-Duty and Medium-Duty Vehicles: Regulatory Impact Analysis", EPA-420-R-24-004, March 2024; and "Greenhouse Gas Emissions Standards for Heavy-Duty Vehicles: Phase 3: Regulatory Impact Analysis, EPA-420-R-24-06, March 2024.

same as those used in the final LMDV and HD GHG Phase 3 rules and in the estimates presented in Table A- 1. The analysis presented below discusses results in comparison to the results the EPA projected in the 2024 LMDV and HDP3 final rules, which included the IRA tax credits and the ACT rule.

For the analysis presented here, we removed the following IRA tax credits after 2025: the credits for purchasing (30D) and leasing (45W) LD and MD battery BEVs, battery production tax credits (45X) for LD, MD, and HD BEVs and HD fuel cell EVs (FCEVs), vehicle purchase tax credits (45W) for HD BEVs and HD FCEVs, and the tax credit for EV supply equipment (EVSE) installation (30C) for HD BEVs. This analysis has some overlap with actions recently signed into law in the OBBB. For example, while the OBBB eliminates the IRA tax credits in 30D, 45W, and 30C, the OBBB modified but did not eliminate the battery production tax credits in 45X.

For purchasers of LD, MD, and HD ZEVs,[51] the removal of the purchasing and leasing credits would lead to higher purchasing costs. For LD, MD, and HD vehicle manufacturers, the removal of the battery tax credits would result in higher manufacturer costs per ZEV. These costs are likely passed on to consumers/purchasers, decreasing the demand for ZEVs compared to a scenario in which the tax credits are in place. HD purchasers also face further increased costs resulting from the removal of the Electric Vehicle Supply Equipment (EVSE) tax credits. Consequently, without the IRA tax credits, LD, MD, and HD purchasers would be less likely to purchase a ZEV due to the higher price.

In this updated analysis, we also removed the impacts of the California ACT rule. We modeled reduced adoption of HD BEVs and FCEVs in California and other states that had adopted ACT, consistent with how we modeled ZEV adoption in non-ACT states in the final HD GHG Phase 3 analysis. In addition, we reduced the long-term adoption of HD BEVs and FCEVs across all states to account for expected lower investment resulting from the repeal of IRA incentives for ZEVs and supporting infrastructure. Altogether, removing the IRA tax credits and the ACT rule leads to reduced estimates of HD ZEV populations in the action case (removing the GHG standards) for this 2025 NPRM alternative analysis.

[51] For the purposes of this discussion, ZEVs refer to LD, MD, and HD BEVs and HD FCEVs.

*Table A- 2: Net monetized impacts of the proposal after removing IRA tax credits and the CA ACT rule (billions of 2022 dollars)**

| | 2055 | Present Value at 3% | Present Value at 7% | Annualized Value at 3% | Annualized Value at 7% |
|---|---|---|---|---|---|
| Vehicle Technology | $35 | $800 | $500 | $42 | $41 |
| Electric Vehicle Supply Equipment & Replacements | $15 | $230 | $130 | $12 | $11 |
| Fuel, Repair, Maintenance, Insurance, etc. | ($160) | ($1,300) | ($650) | ($70) | ($53) |
| Energy Security, Refueling Time, & Drive Value | ($6.5) | ($69) | ($36) | ($3.6) | ($2.9) |
| Net Monetized Impacts | ($110) | ($350) | ($52) | ($18) | ($4.1) |

* Positive values reflect savings due to the proposal (i.e., decreases in social costs) while negative values reflect increases in social costs.

As shown in Table A- 2, the updated analysis without IRA tax credits and the ACT rule shows an increase in the estimated net societal costs associated with rescinding GHG standards for LD, MD, and HD vehicles of about $350 billion over calendar years 2027 through 2055 at a three percent discount rate. This reflects an increase in net societal costs of about $90 billion compared to the analysis that includes the tax credits and ACT rule, as seen in Table 3 ($260 billion). This change is largely driven by higher fuel consumption and associated fuel costs in the updated analysis ($1,300 billion vs $1,100 billion), which is greater than the reduction in vehicle technology costs (-$800 billion vs $750 billion). Both increased fuel consumption and technology costs are consistent with the expected impact of the removal of IRA credits and the ACT program. Removing both impacts lead to reduced penetration of BEVs in the action case (i.e., without any GHG standards), while having relatively little impact on BEV penetration in the no action case (i.e., where BEV adoption is driven by Federal GHG standards).

In evaluating these results, it is also important to note that in the updated analysis, ***in the absence of IRA credits, the LD industry is not compliant in model year 2032*** where the BEV adoption rate is not sufficient to keep pace with the year-over-year increases in stringency of the GHG standards set in the LMDV rule. As a result, the MY 2032 GHG industry-wide compliance value is approximately 11 percent higher than the GHG target for that year. These results are different from the analysis that includes IRA tax credits in which the LD industry is compliant with the GHG standards in every year. Our modeling projects that the industry does comply with the MY 2033 and later GHG standards as more lead time and continued technology cost reductions allow additional technologies to be considered and purchased by consumers at lower cost, and manufacturers continue to take advantage of GHG averaging, banking, and trading flexibilities.

It is important to note that our modeling does not account for all possible manufacturer compliance strategies which firms may adopt to ensure compliance with the vehicle GHG standards in the absence of the significant incentives included in the 2022 IRA. In reality, non-compliance in 2032 would likely not play out as the model projects. Instead, the LD manufacturers would likely use a variety of strategies that were not included in our modeling. For example, manufacturers might adjust the product mix by limiting vehicle offerings of the highest emitting vehicles and/or lowering prices of the lowest emitting vehicles. Manufacturers might also generate additional credits in the earlier years to be carried forward to 2032 when the GHG standards are most stringent. We have not modeled the impacts of these alternative compliance approaches, including how limiting or eliminating the sales of the highest emitting vehicles to ensure compliance would impact the automobile companies, automobile workers, dealerships, and consumers; nor have we assessed the program's costs, benefits, and other impacts. Additionally, the model does not account for finance costs or issues with affordability to account for the increased need for sales in earlier years.

Similar to the LD and MD modeling, the HD truck model only evaluates a single compliance strategy in the HD GHG Phase 3 analysis. The HD model uses a technology acceptance model based on payback periods of ZEV technologies.[52] Without IRA tax credits and the California ACT Rule, HD ZEV purchasers would experience longer payback periods for adopting ZEV technologies than modeled in the HD GHG Phase 3 analysis, impacting the acceptance of the technologies in the market. The estimates of average payback period without the IRA tax credits and as estimated in the HD GHG Phase 3 final rule, which includes IRA tax credits are shown in Table A- 3.

*Table A- 3: Average payback period (years) of MY 2032 HD ZEVs before and after removal of the IRA tax credits (45X, 45W, and 30C)*

| | **2024 Analysis with IRA Tax Credits** | **2025 Analysis without IRA Tax Credits** |
|---|---|---|
| Light Heavy-Duty Vocational Vehicles | 2 | 3 |
| Medium Heavy-Duty Vocational Vehicles | 3 | 4 |
| Heavy Heavy-Duty Vocational Vehicles | 4 | 6 |
| Day Cab Tractors | 2 | 5 |
| Sleeper Cab Tractors | 5 | 11 |

In the analysis that removes the IRA tax credits and California's ACT rule, the longer payback periods of ZEV technologies ***lead the model to project that the HD industry would not be in compliance with the existing MY 2027 through MY 2032 and later standards.*** For this scenario, we did not revise the technology assessment for the no-action case ( with standards) and instead assume that HD vehicle purchasers would continue to purchase HD ZEVs under much longer payback periods. It is plausible that what would more likely happen under these circumstances is that manufacturers may restrict sales of higher emitting vehicles or substitute other technologies, such as hybrid vehicles, to comply with the standards. We have not modeled the impacts of how limiting or eliminating the sales of the highest emitting vehicles (in general, gasoline and diesel-fueled vehicles) in order to ensure compliance would impact the HD vehicle manufacturers, HD vehicle workers, dealerships, fleets, and other purchasers; nor have we assessed the impacts on the program's costs, benefits, and other impacts.

[52] Payback period is the amount of time it takes for the lower annual operational costs of a ZEV to offset the higher upfront cost of the ZEV technologies.

## Appendix A.3: Impact of reducing fuel prices

In DRIA Chapter 3, we present a range of projected future gasoline and diesel fuel prices comparing AEO 2023 and two scenarios estimated in AEO 2025, as well as a discussion of how these prices relate to the fuel prices used in the 2024 vehicle rulemaking analyses. The results presented in Table A- 4 contain the same assumptions as those in Table A- 2 (namely, they do not include the IRA tax credits or the ACT rule), with the exception of fuel prices. For this scenario, we reduced the AEO 2023 fuel price projections by $0.25 per gallon for diesel and $1.00 per gallon for gasoline. With these lower fuel costs, we estimate a decrease in the estimated net societal costs associated with rescinding GHG standards for LD, MD, and HD vehicles of about $160 billion over calendar years 2027 through 2055 at a three percent discount rate. Unlike the results using AEO 2023 fuel prices shown in Table A- 2, the combined reduction in vehicle technology costs – $800 billion – and EVSE costs – $230 billion – now exceeds the increase in fuel costs – $820 billion. We note that we did not model potential impacts that lower fuel prices would have on manufacturer decisions for vehicle technologies, nor did we model how lower fuel prices would affect consumer demand and manufacturer decisions which might lead to a different mix of vehicle models, technology adoption, and BEV penetration. The results shown in Table A- 4 were developed using the same fleet of new vehicles that were estimated for Table A- 2. In other words, the differences from Table A- 2 are solely the result of differences in owning and operating vehicles over their lifetimes, and not the result of differences in new vehicle production.

*Table A- 4: Net monetized impacts of the proposal after removing IRA tax credits and the CA ACT rule and using lower projected fuel prices (billions of 2022 dollars)**

| | **2055** | **Present Value at 3%** | **Present Value at 7%** | **Annualized Value at 3%** | **Annualized Value at 7%** |
|---|---|---|---|---|---|
| Vehicle Technology | $35 | $800 | $500 | $42 | $41 |
| Electric Vehicle Supply Equipment & Replacements | $15 | $230 | $130 | $12 | $11 |
| Fuel, Repair, Maintenance, Insurance, etc. | ($110) | ($820) | ($390) | ($43) | ($32) |
| Energy Security, Refueling Time, & Drive Value | ($5.1) | ($55) | ($28) | ($2.8) | ($2.3) |
| Net Monetized Impacts | ($66) | $160 | $220 | $9 | $18 |

* Positive values reflect savings due to the proposal (i.e., decreases in social costs) while negative values reflect increases in social costs.

## Appendix A.4: Impact of accounting for 2.5 years of fuel savings

DRIA Chapter 5 presents a summary of literature on how consumers value future fuel costs at the time of vehicle purchase. As discussed, some of these studies suggest that that buyers may fully value the future fuel cost savings from a vehicle with improved fuel economy, in which case the entire benefit from private fuel savings is incorporated in the buyers' purchase decisions. Other studies suggested buyers do not fully value the future fuel cost savings from improved fuel economy, and only part of the private future fuel savings would be incorporated into the purchase decision. In this section, we present the monetized net impacts of this proposed action under the assumption that consumers' willingness to pay for the change in fuel economy is consistent with the fuel cost impacts during the first 2.5 years after new vehicle purchase. To estimate the results accounting for only the first 2.5 years of fuel savings, we scale the fuel cost impacts from scenarios 2 and 3 using an estimate of the portion ofVMT in the first 2.5 years of the full vehicle life. For this analysis, we use the vehicle mileage accumulation assumptions used in our effects modeling. For the average LD and MD vehicle, about 21 percent of driving occurs during the first 2.5 years of vehicle life, whereas for HD vehicles, this value is about 20 percent. For the results presented in this section, we represent 2.5 years of fuel costs by scaling the combined lifetime fuel costs of LD, MD, and HD vehicles estimated in scenarios 2 and 3 by 21 percent.

### Appendix A.4.1 Accounting for 2.5 years of fuel savings using AEO 2023 fuel prices

The results presented in Table A- 5 are based on the same modeling as Table A- 2 (no IRA tax credits or ACT rule), with the exception that for this estimate, fuel cost impacts are scaled to 21 percent of the full lifetime values. We estimate a decrease of about $380 billion in net societal costs over calendar years 2027 through 2055 at a three percent discount rate. This societal cost savings is greater than the $160 billion estimate shown in Table A- 2 due to the smaller costs related to lost fuel savings due to this proposal compared to scenario 2.

*Table A- 5: Net monetized impacts of the proposal after removing IRA tax credits and the CA ACT rule, with 2.5 years of lifetime fuel costs (billions of 2022 dollars)**

| | **2055** | **Present Value at 3%** | **Present Value at 7%** | **Annualized Value at 3%** | **Annualized Value at 7%** |
|---|---|---|---|---|---|
| Vehicle Technology | $35 | $800 | $500 | $42 | $41 |
| Electric Vehicle Supply Equipment & Replacements | $15 | $230 | $130 | $12 | $11 |
| Fuel, Repair, Maintenance, Insurance, etc. | -$78 | -$590 | -$280 | -$31 | -$23 |
| Energy Security, Refueling Time, & Drive Value | -$6.5 | -$69 | -$36 | -$3.6 | -$2.9 |
| Net Monetized Impacts | -$34 | $380 | $320 | $20 | $26 |

* Positive values reflect savings due to the proposal (i.e., decreases in social costs) while negative values reflect increases in social costs.

### Appendix A.4.2 Accounting for 2.5 years of fuel savings using reduced fuel prices

Table A- 6 is based on the same modeling as Table A- 5, with the additional assumption that future fuel prices will be lower than the projections in AEO 2023. As with scenario 3 (Table A- 4), this scenario reduces the AEO 2023 fuel price projections by $0.25 per gallon for diesel and $1.00 per gallon for gasoline. In this scenario, we estimate that the removal of GHG standards will result in a decrease of about $490 billion in net societal cost over calendar years 2027 through 2055 at a three percent discount rate.

*Table A- 6: Net monetized impacts of the proposal after removing IRA tax credits and the CA ACT rule and using lower projected fuel prices, with 2.5 years of lifetime fuel costs (billions of 2022 dollars)**

| | **2055** | **Present Value at 3%** | **Present Value at 7%** | **Annualized Value at 3%** | **Annualize d Value at 7%** |
|---|---|---|---|---|---|
| Vehicle Technology | $35 | $800 | $500 | $42 | $41 |
| Electric Vehicle Supply Equipment & Replacements | $15 | $230 | $130 | $12 | $11 |
| Fuel, Repair, Maintenance, Insurance, etc. | ($69) | ($490) | ($230) | ($26) | ($19) |
| Energy Security, Refueling Time, & Drive Value | ($5.1) | ($55) | ($28) | ($2.8) | ($2.3) |
| Net Monetized Impacts | ($25) | $490 | $380 | $26 | $31 |

* Positive values reflect savings due to the proposal (i.e., decreases in social costs) while negative values reflect increases in social costs.

# Appendix B: Results using a revealed preference approach

## A. Key facts pointing toward enormous costs of compliance with the 2024 rules

Key facts point to enormous compliance costs and the need for a more market-oriented approach to assessing costs and benefits. Overall, these analyses further support the reasonableness of the proposed rule and the unreasonableness of the existing rule.

The approaches in this Appendix emphasize revealed preference, particularly when assessing the per-vehicle costs of tighter emissions standards. They all share the same framework – a "derived demand" representation of the markets for vehicles. They differ in terms of which of two data sources are used to quantify the willingness of consumers to accept EVs instead of vehicles powered with internal combustion engines (ICE vehicles). One source is an earlier EPA rulemaking. The alternative source is an investigation of inter-manufacturer regulatory credit trades by the White House Council of Economic Advisers (CEA) in connection to the SAFE rule.

The estimates here differ markedly from those in the 2021 rule (86 FR 74434) and, especially, the 2024 vehicle rulemakings. Except where specifically indicated in what follows, all of the deviations between this DRIA's estimates and the 2024 vehicle rulemaking RIAs are due to the EPA's assumptions related to supply, demand, incentives, and market equilibrium. The accuracy of previous assumptions about links between worldwide emissions and future climate bears little relationship to the fact that these are proper ingredients of benefit-cost analysis.

### 1. Market size and importance

A key economic fact about the U.S. market for LD vehicles is its sheer size. Sixteen million new vehicles are sold annually, with consumers spending almost $800 billion on them. The consumer value created significantly exceeds expenditures, reflecting substantial consumer surplus. That is, cars and light trucks offer more than transportation—they deliver freedom, mobility, and reliability. For many Americans, obtaining a driver's license remains one of life's most memorable milestones.

Beyond fuel efficiency, vehicle buyers value affordability, safety, reliability, driving performance, and much more. All this points to the fact that a government-driven radical transformation of the market would be enormously costly. The price tag—likely in the hundreds of billions annually and thereby several trillion in net present value—cannot be justified without demonstrating even greater benefits. Conversely, any benefit-cost analysis that acknowledges costs of only a few percent of revenue is detached from the realities of the American vehicle market and the reasons consumers choose to own cars and light trucks.

Although less personal, MD and HD vehicle markets nonetheless deliver consumer surplus by enabling businesses to provide a range of goods and services at prices and locations that better appeal to consumers.

## 2. The indirect and incidental relationship between "emissions standards" and market wide emissions

A key economic fact about the 2021 and 2024 vehicle rulemakings is they rewarded the sale of EVs while penalizing the sale of ICE vehicles, rather than penalizing vehicle owners in proportion to the fossil fuels that they burn. That is, the link between the rules' economic incentives and total emissions from regulated-vehicle markets is indirect and incidental.

Under the 2021 and 2024 LD vehicle rules, the market wide sales-weighted average of regulatory coefficients must be less than the EPA's target. The regulatory coefficients, expressed in grams per mile, are assigned by the rules according to laboratory test-cycle measurements for various vehicle designs. The average for a particular manufacturer in a particular segment (by footprint, car versus truck) may exceed the target, but the manufacturer must ultimately compensate by falling short of the target in other segments or purchasing credits from another manufacturer with an average below the target.[53]

The regulatory coefficient applicable to a particular vehicle's sale is not connected to the fossil fuels used by that vehicle after it leaves the showroom. Two vehicles with the same regulatory coefficient can result in vastly different fossil-fuel usage. One may be driven intensely for decades, while the other is put on display in a museum never to be driven again. One may primarily carry light payloads on highway trips, while the other primarily carries heavy payloads between intra-city destinations. Among a pair of EVs, one may primarily be charged from a grid particularly reliant on coal-fired power plants while the other is charged in a nuclear-intensive grid.

In addition, the regulatory coefficients only count tailpipe emissions, whereas, from the perspective of climate change, there is little difference between a ton of emissions from a tailpipe and a ton emitted upstream at electric power plants.[54] ICE vehicles and EVs are completely different in terms of the distribution of their emissions between tailpipe and power plant. Indeed, the regulatory coefficient for EVs was set to zero by the 2021 and 2024 vehicle rulemakings. These are all reasons why, from an economic perspective, the 2021 and 2024 vehicle rulemakings should be understood as incentivizing EV sales and only indirectly and incidentally incentivizing reduced GHG emissions.

A reliable economic analysis must also recognize that fossil fuels are traded in a world-wide market. The majority of fossil fuel use, even within the U. S., occurs outside the jurisdiction of the EPA vehicle-emissions rules. Through market forces, discouraging fossil fuel use by U.S. vehicles will encourage additional fossil fuel use elsewhere in the U.S. and world economies. Transportation might shift from cars to short-haul air travel with higher emissions per passenger mile. It may shift from trucks to railroad or ships that partially offset the reduce emissions from trucks.[55] Through international trade, the U.S. economy might substitute toward more urban-intensive industries that

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[53] This occurs through the EPA's Averaging, Banking, and Trading program, which also allows for deviations from the target in a particular year to be offset by opposite deviations in adjacent years. Less stringent compliance pathways are available for small volume manufacturers.

[54] The location of emissions is relevant for the health consequences of particulate-matter emissions.

[55] The offset may be more than 100 percent depending on the type of emission and mode of transport used instead of trucks.

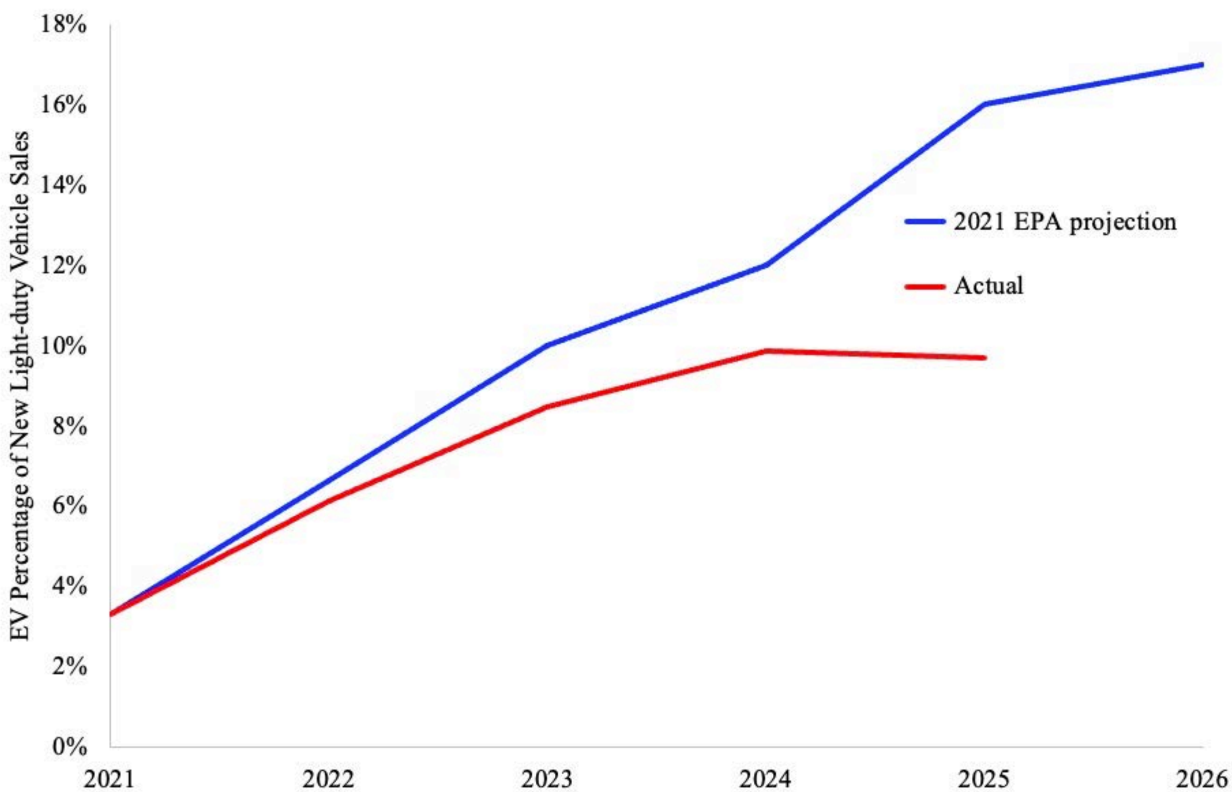
involve less LD vehicles in exchange for foreign economies shifting in the other direction. "Leakage" of this sort would at least partially offset emissions reduction among U.S. vehicles. It is possible that the offset would be more than 100 percent. The 2021 and 2024 vehicle rulemakings failed to account for either of these possibilities.

## 3. EPA 2021 and 2024 systematically over-estimated consumer acceptance of EVs

The resource and opportunity costs of the 2021 and 2024 vehicle rulemakings especially depend on the ease with which consumers accept EVs. If enough consumers viewed EVs and ICE vehicles as essentially equivalent, regulation might increase EV market shares with little increase in the price of ICE vehicles or little decrease in the price of EVs. But that is not the reality of U.S. vehicle markets.

Figure RIA-1 shows two time series for EV market shares for model years. The upper series is the projection from the EPA's 2021 rule. The share would increase every year, reaching 16 percent in model year 2025 from only three percent only four years prior. In fact, the lower series shows that the EV share has yet to exceed 10 percent. So far, the 2025 MY share looks to be slightly below the share from 2024.

**Figure RIA-1: 2021 EPA Overestimates Consumer Acceptance of EVs**
(Battery electric + Plug-in Hybrids)




Despite emerging evidence to the contrary, in early 2024 the EPA doubled down on its assumed ease of substitution toward EVs, predicting that "that electrification of the light-duty vehicle market will [] accelerate dramatically."[56] Meanwhile, another part of the Federal government offered less optimistic predictions about the costs of EV adoption. CEA used market prices to quantify the costs of emissions standards of the kind that would ultimately be imposed by the 2021 and 2024 LD rules.[57] Especially, CEA concluded that, because most consumers do not see EVs and ICE vehicles as close substitutes, the standards would sharply increase the inter-manufacturer-market price of regulatory credits from $86 per ton of $CO_2$ to well over $100 per ton. This appears to have occurred.[58]

Under the Regulatory Flexibility Act and E.O. 13563, the EPA has a duty to consider the "actual results of regulatory requirements" and adjust its rulemaking accordingly. The EPA now acknowledges that the benefit-cost analysis supporting its 2021 and 2024 vehicle rulemakings has been contradicted by reality. We take this opportunity to utilize CEA's market-based approach to assessing costs and benefits.

## 4. Vehicle utilization rates are not necessarily the same for ICE vehicles and EVs, and may be affected by regulations that change consumer access to the vehicles that they prefer

Given consumers' limited willingness to accept an EV instead of an ICE vehicle, they may adjust their utilization rates. In other words, they would react to a scarcity of ICE vehicles by driving the remaining ones more frequently and for more years. That would allow the market to comply with more stringent standards while still providing consumers almost as many miles with ICE vehicles. Indeed, the EPA's 2024 LMDV RIA acknowledges that several studies find that EVs are already driven fewer miles per year than ICE vehicles are, without incorporating that into the benefit-cost analysis.[59]

Current ICE vehicle usage patterns leave plenty of room for increased utilization in response to regulatory incentives. Especially, vehicles are parked more than 90 percent of the time.[60] Consumers can also spend resources extending the life of their ICE vehicles, including the ICE vehicles they purchase in MY 2027 and beyond.

In acknowledgment of the gap between regulatory instruments and the regulatory intent of the 2021 and 2024 vehicle rulemakings, this Appendix allows for the possibility that the EPA's 2021 and 2024 "emissions" standards result in an increase in fossil fuels burned per ICE vehicle and reduction in

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[56] LMDV RIA, p. 4-2, https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P1019VPM.pdf.
[57] The Council of Economic Advisers. (2020). Estimating the Value of Deregulating Automobile Manufacturing Using Market Prices for Emissions Credits: https://trumpwhitehouse.archives.gov/wp-content/uploads/2020/12/CEA_SAFE_Report.pdf.
[58] Also in 2020, three economists from the same CEA predicted negative economic-growth effects of Federal regulation, especially vehicle standards. These predictions also proved correct (https://www.wsj.com/opinion/nobelists-for-harris-are-unburdened-by-proof-9b33ac0f).
[59] LMDV RIA, p. 4-23, https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P1019VPM.pdf.
[60] State of Charge. (2022). Latest EV Charging Station Reviews: https://evchargingstations.com/chargingnews/on-average-vehicles-are-parked-for-95-percent-of-the-day/ citing U.S. Department of Energy data for 2022.

miles driven per EV. Conversely, one effect of ending those standards might be to reduce fossil fuels burned per ICE vehicle even while increasing the number of ICE vehicles sold.

## B. Summary of Costs and Benefits

This Appendix estimates that the total benefits of this proposed action far exceed the total costs with the annualized value of monetized benefits to the U.S. estimated at $157 billion to $444 billion, as shown in Table RIA-1. The annualized costs associated with emissions are estimated to be less than $5 billion, relative to the baseline of retaining the 2009 Endangerment Finding and the GHG vehicle standards that followed. This puts the net benefits of the proposed action in the hundreds of billions annually and more than $1 trillion in net present value.

**Table RIA-1. Summary of Benefits and Costs**
billions of 2022 dollars, annualized over years 2027-2055

| Benefit Category | Range | Cost Category | Range |
|---|---|---|---|
| Opportunity and resource cost savings | | | |
| Vehicle composition | 114-365 | Congestion | 1.2 |
| Vehicle quantity | 17-44 | Fossil-fuel risk | 1.4-2.3 |
| Strained electric grid | 10-21 | PM emissions | 2.2-4.2 |
| Savings on Insurance | 1.8-2.1 | | |
| Savings on EVSE Ports | 14 | | |
| **Total Benefits** | **157-444** | **Total Costs** | **5-8** |

### 1. Resource and opportunity costs: vehicle markets

Most of the benefits of the proposed rule come from having a composition of LD vehicles that is closer to consumer needs and preferences (recall Figure RIA-1).[61] Still, the benefits to MD and HD markets are significant too, especially due to the additional challenges of electrifying them.

Resource costs include, but are not limited to, the "Vehicle technology costs" referenced in the 2021 and 2024 vehicle rulemakings. They include the additional costs of manufacturing EVs that share some of the characteristics that consumers value in their ICE vehicles. Resource costs also include capital equipment, additional maintenance, human time, and effort required to manage a fleet of vehicles whose composition would, under the 2024 vehicle rulemakings, become increasingly divorced from what consumers want to drive.

Table RIA-1's opportunity-cost savings include consumers' value of ICE vehicles that would not have been produced under the 2024 vehicle rulemakings.[62] Although not necessarily related to

[61] Resource and opportunity costs are not reported separately because they are a combined category in the CEA model of the regulatory costs of vehicle-emission standards.
[62] Foregone consumer surplus is an instance of opportunity cost. Traditionally, the EPA has featured foregone consumer surplus in the RIAs of its vehicle-emissions rules. See, for example, 77 FR 62716, 85 24200, and 86 FR 74509. This important cost category, also emphasized in RIA guidance from OMB, was improperly omitted from the 2024 vehicle rulemakings.

vehicles, the concept and importance of opportunity costs became more salient during the COVID-19 pandemic when social distancing meant giving up valuable activities. In-person schooling was among the missed opportunities for millions of children during the pandemic, which is now recognized as a substantial cost. A similar logic applies to vehicle regulation. The 2024 vehicle rulemakings would have eliminated the opportunity to purchase inexpensive ICE vehicles, which is a significant cost to consumers looking for vehicle features that EVs do not have.

We take two approaches to quantifying resource and opportunity costs of the 2024 vehicle rulemakings. One builds on estimates from the earlier EPA emissions rules, such as the 2021 LD rule (86 FR 74434) and the 2011 MD and HD rule (76 FR 57106).[63] The second approach is the examination of inter-manufacturer credit markets undertaken by CEA (2020) for the purpose of assessing the costs associated with vehicle-emission regulations.[64] If enough consumers view ICE vehicles and EVs as functionally interchangeable, then manufacturers will find it relatively easy to comply with a more stringent standard by marketing the EVs, without dropping the EV purchase price or elevating ICE prices, rather than seeking credits from other manufacturers. In this case, tightening the standard results in only a slight increase in the credit prices. If instead credit prices increase markedly as the standard tightens, that is evidence that consumers are unsatisfied with the EPA-prescribed vehicle composition unless they are charged a significant premium for the ICE vehicles.

The analytical details of all approaches are provided in section C of this Appendix. An inescapable fact about the 2024 vehicle rulemakings is that they prescribed changes far beyond U.S. experience. They would have put the stock of LD vehicles on a path toward majority electric from a mere 1.5 percent electric at the time of writing. The MD and HD markets were also expected to become half electric in order to comply with the 2024 vehicle rulemakings. Each of these is at least an order of magnitude change requiring a great deal of extrapolation beyond the historical data, whether it be with the engineering approach taken in the 2024 vehicle rulemakings or the more market-based approach taken here.[65]

For this Appendix, the relationship between credit prices and emissions standards observed by CEA must be extrapolated to levels well beyond what has yet been experienced in the United States. This Appendix also allows for technological progress in vehicle manufacturing that steadily increases the miles per gallon (reduces $CO_2$ grams per mile) for each subsequent MY at the annual rate observed in the EPA's automotive trends data for the model years 1978 through 2011.

This Appendix's estimates of combined savings resource and opportunity cost savings ("benefits") relating to the composition of vehicle fleets range from $114 billion to $365 billion annually. Reducing quality-adjusted vehicle prices also increases consumer surplus by resulting in a greater

[63] 86 FR 74434 (Dec. 30, 2021) "Revised 2023 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions Standards"; 76 FR 57106 (Sept. 15, 2011) "Greenhouse Gas Emissions Standards and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles."
[64] The Council of Economic Advisers. (2020). Estimating the Value of Deregulating Automobile Manufacturing Using Market Prices for Emissions Credits: https://trumpwhitehouse.archives.gov/wp-content/uploads/2020/12/CEA_SAFE_Report.pdf
[65] A separate and more speculative feature of the 2024 vehicle rulemakings, that is much less relevant here, was putting significant weight on climate benefits centuries in the future. The citizens of, say, the year 2200 U. S. have yet to be born and will have access to technologies that we cannot even imagine.

quantity of vehicles. This addition to consumer surplus is an instance of opportunity cost savings. Its amount can be approximated as one half the decline in quality-adjusted price times the increase in quantity.[66] This Appendix's annualized estimate of this addition to consumer surplus ranges from $17 billion to $44 billion.

### 2. Resource and opportunity costs: electricity and labor markets

EV charging can soak up spare generation and transmission capacity that would otherwise power everything from factories to data-center servers to air-conditioning on the hottest days. At a time when only about five percent of California's registered vehicles were electric, state officials urged residents to "avoid … charging electric vehicles" because "California and the West are expecting extreme heat that is likely to strain the grid."[67] The 2024 LMDV rule aimed for 50 percent of LD vehicles nationwide to be EVs, or about ten times the California grid burden. Additional grid burden would come from electrifying MD and HD vehicles.

If the grid runs tight, system operators must either build costly new plants and lines, fire up expensive fossil "peaker" units, or curtail other demand—choices that divert capital and fuel away from alternative uses such as industrial expansion, data-center growth, or deeper decarbonization of existing loads. Consumers may face higher electricity rates or reliability risks, while public dollars earmarked for schools, or get pulled into emergency subsidies and grid upgrades. In short, every extra megawatt-hour (MWh) needed for EVs carries an opportunity cost.

The 2021 and 2024 vehicle rulemakings quantified such opportunity costs by assuming that the rules would have little effect on electricity prices or average costs. In contrast, Fitzgerald and Mulligan (2023) modeled EV charging in the face of renewable energy standards and EPA emission standards for LD vehicles.[68] They assumed that essentially all LD vehicles would become electric, which is more ambitious than the EPA's 2024 target. However, they did not consider any additional electricity demand from the more energy intensive MD and HD vehicles that would also be about half electric under the 2024 vehicle rulemakings.

The Fitzgerald and Mulligan approach assumes that supply meets demand and is allocated to the highest-value uses. The cost of electrifying vehicles would be even greater if it led to blackouts or misallocation of the available supply. With these caveats, this Appendix uses the Fitzgerald and Mulligan estimates. The EPA invites comment on monetizing effects of regulation on the reliability of the electric grid.

Figure RIA-2 is reproduced from Fitzgerald and Mulligan. The green curve represents the supply of electricity generated from renewables. The black curve is the supply of fossil-fuel generated electricity, shown as a mirror so that movements to the right in Figure RIA-2 represent a substitution on the supply side from fossil-fuel generation to renewable energy. The point *a* indicates the quantity and wholesale price of electricity produced from renewable sources under the proposed

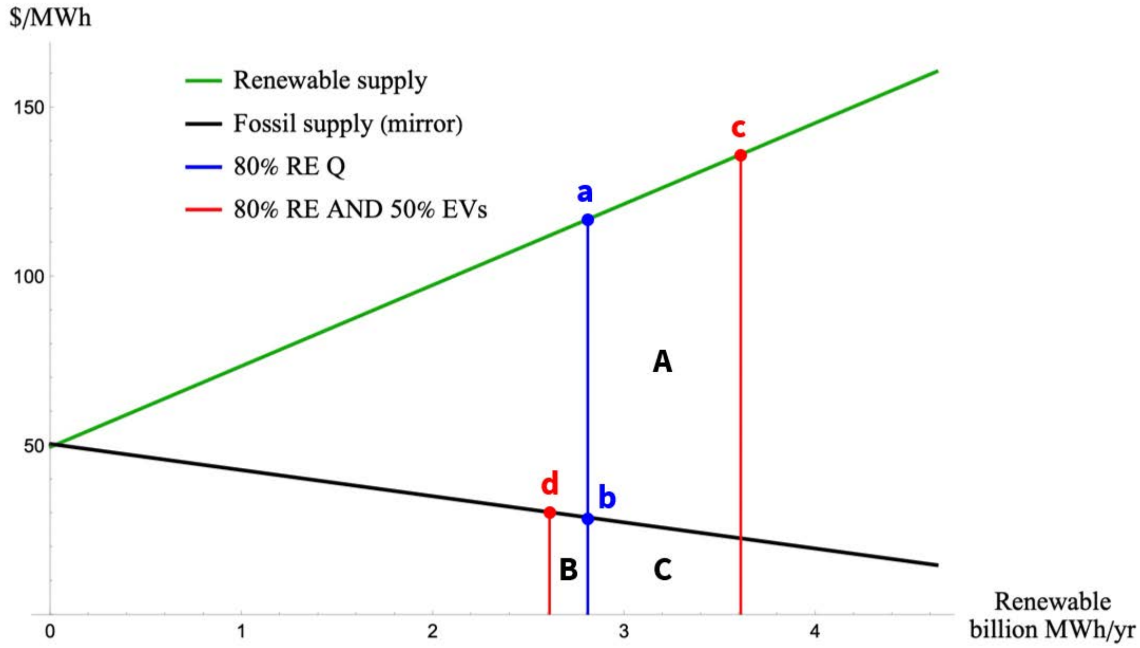
[66] See also 77 FR 62716.

[67] California ISO. (August 30, 2022). "Excessive heat starting tomorrow will stress energy grid" https://www.caiso.com/Documents/excessive-heat-starting-tomorrow-will-stress-energy-grid.pdf.

[68] Fitzgerald, T. and Mulligan, C.B. (2023).The Economic Opportunity Cost of Green Recovery Plans: https://www.nber.org/papers/w30956.

rule, assuming that the Biden administration's 80 percent renewable goal is realized.[69] The point *b* corresponds to fossil-fuel produced electricity under the proposed rule. The points *c* and *d* are their analogues under the baseline of the 2024 vehicle rulemakings. Together, they involve 1 TWh more electricity usage than under the proposed rule.

Figure RIA-2. The Composition of Non-nuclear Electricity Generation




The combined areas *A*, *B*, and *C* measure the proposed rule's annual savings of resources for generating electricity. Part of this savings is already counted in consumer surplus, which reflects the choices of consumers who considered vehicles options at a time when the wholesale price of electricity was about $50 per MWh. The additional cost of $57 per MWh would either require government subsidies, or be passed onto consumers. In aggregate, the additional cost shown in Figure RIA-2 would amount to $57 billion annually.

To the extent that the quantity of EVs increases even without regulatory incentives, or the EV share of the stock has yet to catch up to the EV share of new sales, only part of the $57 billion applies. As explained further in Section C.5, the annualized cost savings reported in Table RIA-1 ranges from $10 billion to $21 billion, depending on the scenario.

Vehicles are an important part of travel between home and the workplace. For many workers, vehicles are part of the tasks they perform at work. Interference with vehicle markets therefore has the potential to reduce employment, in some of the same ways that a tax on employment would.

[69] Because stationary sources are not part of this rulemaking, the renewable energy goals are treated as constant. Nevertheless, Figure RIA-2 begins to show how the costs of vehicle rules accumulate on top of the costs of electricity rules. Under the Regulatory Flexibility Act, E. O. 12866, and E. O. 13563, Federal agencies have a duty to "give consideration to the cumulative effects of their own regulations, including cumulative burdens."

Especially, the already-taxed labor market is further burdened by the additional costs of acquiring desirable vehicles. The EPA seeks comment on quantifying those potentially important effects, which would add to the benefits of the proposed rule that are already quantified.

## 3. Tailpipe emissions: physical quantities

U.S. vehicles are not, and will not be, the only source of GHG and PM emissions. It is therefore essential to anticipate the effect of vehicle regulations on other emission sources. The 2024 vehicle rulemaking recognized vehicle-market emissions substitution in the form of shifts toward EVs that increase the demand for fossil fuels by the electricity-generation sector. This Appendix assumes that eliminating GHG standards for vehicles would reduce fossil-fuel use for electricity generation, and the accompanying $CO_2$ and PM emissions, by the same amount that the 2024 vehicle rulemaking assumed that it increased. The reduction could be even greater to the extent that the proposed rule would reduce EV utilization rates below even the 2024 vehicle rulemaking's baseline, or that the fossil-fuel intensity of electricity supply is now expected to be above the EPA's 2024 projections. [70]

Another source of substitution in the vehicle market is changes in the intensity of use. As the 2024 vehicle rulemakings would, by design, create a shortage of ICE vehicles and a surplus of EVs, per-vehicle utilization of ICE vehicles would increase while utilization of EVs would fall. Eliminating GHG standards for vehicles would have the opposite effect.

ICE vehicle usage patterns leave plenty of room for increased utilization rates in response to regulatory incentives. Especially, vehicles are parked more than 90 percent of the time.[71] Consumers can also spend resources extending the life of their ICE vehicles, including the ICE vehicles they purchase in MY 2027 and beyond. Cuba is world-famous for its extension of vehicle lives; after it lost access to American-made automobiles and parts in 1962,it became incredibly resourceful in maintaining and modifying the vehicles to keep then running.[72] Analogous, albeit less extreme, behavior should be expected in the U.S. if its regulations were to mandate vehicle production that departs sharply from consumer preferences.

This Appendix assumes that the elasticity of the ICE-vehicle utilization rate, as a ratio to the EV utilization rate, has an elasticity of 0.3 with respect to the number of registered EVs per registered ICE vehicle. In other words, the utilization-rate changes occur, but not enough to fully offset the reduction in ICE quantities that result from GHG standards. Indeed, 0.3 is closer to no change than a full offset.

Substitution will also occur in fossil-fuel markets. Vehicle regulation shifts one component of fossil-fuel demand, which unmistakably spills over onto supply and other elements of fossil-fuel demand.

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[70] LMDV RIA, Figure 5-6, https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P1019VPM.pdf. The figure indicates a 70 percent reduction in $CO_2$ emissions in its baseline power sector that would be generating at least 40 percent more electricity by the year 2050.

[71] Vehicles are real capital goods. In recognition that capital utilization rates vary, one of the most closely watched statistics regarding real capital goods are "capacity utilization rates."

[72] Enoch, M. P.et al. (2004). The Effect of Economic Restrictions on Transport Practices in Cuba: Transport Policy 11, no. 1, 67–76: https://oro.open.ac.uk/2531/4/Enoch_Warren_TP_11.pdf.

The other elements of demand include heating, cooking, industrial processes, agriculture, other forms of U.S. transportation such as air travel, and vehicle use outside the U. S.. This Appendix translates U.S.-vehicle emissions impacts into worldwide emissions using fossil-fuel supply and demand, described more fully in section C.5 of this Appendix. The ultimate conclusion is that half of the reduction of fossil-fuel use by U.S. vehicles–whether it be from powering ICE vehicles or generating electricity for EVs–is offset by increased fossil-fuel use elsewhere in the world economy.

For the purposes of projecting U.S. PM emissions, it matters whether where the offset occurs. That is, part of the GHG emissions offset is not an offset for U.S. PM emissions because some of the change in fossil-fuel use is outside the U. S.. The EPA seeks comment on quantifying this part. For the purposes of this DRIA, this Appendix assumes that all of the offset is outside the U.S., or in a part of the U.S. that does not affect U.S. health. This assumption serves to exaggerate the U.S. increase in PM emissions that would result from this proposed action.

## 4. Monetization of particulate emissions

The discount rate for comparing near- and long-term costs and benefits should reflect the intertemporal prices that households and businesses trade at, rather than a government bond yield. It is the households and businesses that pay the costs of GHG policies and experience the benefits of reduced emissions in the future. That is why OMB guidance recommends agencies to use three and seven percent annual discount rates.

This Appendix estimates that, by increasing PM emissions, the proposed action would lead to health costs of $2 billion to $4 billion annually, on average. These estimates are of less magnitude than the $10 billion $PM_{2.5}$ cost-reduction reported in the 2024 LMDV rule for two reasons. One is the aforementioned emissions offsets in vehicle markets. The second is that much of the $10 billion reported in the 2024 LDMD rule was due to criteria pollutant standards that are unchanged by this proposed action.

The EPA does not attempt to monetize the value, if any, of changes in GHG emissions that result from the proposed action. However, the EPA notes that any reliable estimate of that value would be orders of magnitude less than the benefits of the proposed action, for the reasons already cited.

## 5. Additional costs of the proposed actions

This Appendix maintains its modeling of fossil-fuel risks, but recognizes that the proposed action will increase U.S. fossil-fuel demand less than the 2024 vehicle rulemaking projected to decreased it due to changes in vehicle utilization rates. This annualized cost is estimated at about $1 billion to $2 billion.

Fossil-fuel risk was labeled “energy security costs” in previous rules. However, our results suggest that a strained electricity grid is also a significant risk from no action, and therefore relabel the item to avoid ambiguity.

The proposed action is expected to increase vehicle congestion due to increased vehicle sales that result from reduce quality-adjusted vehicle prices. The EPA seeks comment on whether, and how much, the proposed action might affect vehicle congestion by encouraging supply and quality of roads and related infrastructure as the vehicles used for infrastructure investment become cheaper and better quality (relative to no action). This Appendix's estimate of congestion costs is about $1 billion annually.

## 6. Additional benefits of the proposed actions

Insurance costs are a cost of vehicle ownership beyond what is spent at new-vehicle dealers. This Appendix maintains the assumption that insurance costs over the lifetime of a new vehicle are proportional to expenditures on purchasing new vehicles. With the proposed action reducing vehicle prices by a greater percentage than it increases vehicle quantities, the result is an insurance saving of almost $2 billion annually.

The proposed action would reduce the number of EVs relative to the baseline. This Appendix maintains the modeling of LD and MD EV charging ports (cited as "EVSE ports" in Table RIA-1), but scales up the total to include HD vehicles as well. We find an annualized savings of $14 billion. The EPA seeks comments on whether and how that modeling should be updated given the low EVSE installation rate in response to Federal programs subsidizing EV infrastructure.[73]

## 7. Fuel expenditure and "drive value" in a revealed-preference model

In order to avoid double counting, Table RIA-1 does not have an additional cost or benefit for fuel expenditures. A consumer fully cognizant of the fueling requirements of an ICE vehicle may nonetheless prefer the ICE vehicle because it offers other features with value more than offsetting the required fuel expenses. A rule that increased ICE prices enough for the consumer to switch to EV is a consumer harm, not a "benefit" equal to the consumer's reduced spending on fuel. The savings on fuel is more than offset by the loss of access to the ICE's vehicles features. With the net of these two categories already captured by consumer surplus, adding to the benefit-cost analysis an estimate of one without an estimate of the other would substantially distort the results.[74]

Another approach would be to assume that consumers are unaware of the fuel expenses associated with ICE vehicle purchases. Such an assumption may be at odds with empirical evidence.[75] Even if it weren't, the solution would be to improve consumer information.[76] This approach would also overlook the immense heterogeneity among consumers, whose diverse

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[73] International Energy Agency. (2025). Electric vehicle charging: https://www.iea.org/reports/global-ev-outlook-2025/electric-vehicle-charging.

[74] The net of these two is essentially an increase in the quality-adjusted price, as shown by the microeconomics result known as "Shephard's Lemma."

[75] See the literature cited in Section 5 of this DRIA. As noted by the 2011 HDV RIA, p. 9-2, it is even more suspect when the buyers are businesses, for which "we generally expect firms to attempt to minimize their costs in an effort to survive in a competitive marketplace, and therefore to make decisions that are in the best interest of the company and its owners and/or shareholders."

[76] OMB Circular A-4 (https://obamawhitehouse.archives.gov/omb/circulars_a004_a-4) encourages "informational measures rather than regulation." It concludes that "a particularly demanding burden of proof is required to demonstrate the need for …mandatory uniform quality standards for goods or services if the potential problem can be adequately dealt with through voluntary standards or by disclosing information of the hazard to buyers or users." To be clear, Circular A-4 does not assert that information alone is necessarily adequate to address market failures associated with externalities, which is why this proposed action includes environmental costs in its regulatory-impact calculus.

circumstances—such as varying commuting distances, access to charging infrastructure, household budgets, climate conditions, and even preferences for vehicle features like towing capacity or off-road capability—profoundly shape their choices. As a Federal environmental agency, the EPA lacks the granular, real-time knowledge of the individual contexts that consumers themselves navigate daily through their decisions.

Under the consumer-surplus approach, results are somewhat less sensitive to forecasts for fuel and electricity prices. On the other hand, the forecasts matter for quantifying opportunity costs of the proposed action whether and to what degree market forces beyond the rule will contribute to the adoption of EVs. We allow for technological progress in vehicle manufacturing that steadily increases the MPG (reduces $CO_2$ grams per mile) for each subsequent MY at the annual rate observed in the EPA's automotive trends data for the model years 1978 through 2011.

The 2024 vehicle rulemaking refers to "drive benefits," which can be interpreted as one element of consumer surplus. The RIA for this action includes consumer surplus more broadly. The benefit item "vehicle quantity" shown in Table RIA-1 is particularly close to the concept of "drive benefits."

# C. Economic models of regulatory impact

Fundamentally, the economic models used in this Appendix to analyze this action are supply and demand models. The supply of vehicles reflects processes of innovation, manufacturing, and retailing, subject to regulatory constraints. Demand for vehicles derives from demand for transportation, freedom, mobility, reliability, and other characteristics valued by household- and commercial-owners of vehicles. The vehicle-market piece of the analysis is sufficient by itself to estimate a significant portion of the resource and opportunity costs of vehicle-emission standards.

Emissions impacts cannot be reliably quantified without considering the worldwide market for fossil fuels. Vehicle regulation shifts one component of fossil-fuel demand, which unmistakably spills over onto supply and other elements of fossil-fuel demand. This Appendix translates fleet emissions impacts into worldwide emissions using fossil-fuel supply and demand.

## 1. Vehicle supply and demand: the EV share

Vehicle-emissions regulations are imposed on new vehicles. Resource and opportunity costs are calculated once for each cohort of new vehicles. The calculation begins by letting $B$ ("battery") and $X$ denote the market-level quantities of new EVs and ICE vehicles, respectively. Because effects of new vehicle production on the entire stock of registered vehicles only appear later when accounting for emissions, we omit MY subscripts.

Although this Appendix derives cost formulas in this two-type setting, the two-type cost formulas also describe models with an arbitrarily large number of vehicle types.[77] For benefit-cost estimation

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[77] The many-vehicle case would be analyzed with vectors, which we demonstrate in this footnote and elsewhere confine our analysis to the two-type case. The vector analysis lets $q$ denote a (potentially long) vector of market quantities of vehicle models, which differ in many characteristics including emissions. The GHG standards affect these quantities, including setting some of them to zero as vehicles leave the market and moving others off of zero as vehicles enter. Let $p$, $c$, and $g$ denote the corresponding vectors of retail

purposes, we therefore summarize the regulatory coefficients for ICE vehicles as a single constant $g$. As already noted, the coefficient for EVs is zero. Therefore, with a market-level emissions target of $G < g$, the market-level regulatory constraint is:

$$gX \leq (B + X)G \tag{1}$$

*G* is a policy parameter while *B* and *X* are market outcomes. Stricter standards correspond to values of *G* closer to zero. The regulatory constraint (1) has an equivalent representation as a constraint on the quantity share *B*/(*B*+*X*):

$$\frac{B}{B + X} \geq 1 - \frac{G}{g} \tag{2}$$

Henceforth, the regulatory constraint (2) is assumed to hold with equality. It is an arithmetic demonstration of the earlier conclusion that emissions regulation directly encourages sales of EVs and discourages sales of ICE vehicles.  How the vehicles are driven after they leave the showroom, or where EV owners source their electricity, matters a great deal for real-world emissions. Nevertheless, those factors are absent from the regulatory constraint.

The policy parameters corresponding to the quantitative results for the revealed-preference approaches are shown in Table RIA-2.[78] Note that the units are different for HD standards than for the other two classes.

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prices, marginal production costs, and GHG emissions (i.e., the regulatory coefficients), respectively. With one-for-one pass through of costs to retail prices, we have $p = \mu + c + (g–G)\lambda$, where *G* and $\lambda$ are scalars denoting the emissions standard and the equilibrium price of a GHG credit. $\mu$ is a vector of vehicle-specific markups that, by the pass-through assumption, are independent of the GHG standard. If the GHG standard is binding and dot indicates vector dot product, then $g \cdot q = Gq$, which means that specific vehicles can deviate from the standard but the market sales-weighted average emissions does not. It follows that the standard *G* has a retail price effect that varies across vehicles. The sales-weighted retail price impact is simply the scalar $-\lambda$. In words, the average price effect of a stricter standard (lower *G*) is exactly the GHG credit price $\lambda$, regardless of whether there are just two vehicle types or many.

[78] No-action standards are sourced from 89 FR 27854 (LD), 86 FR 28081 (MD), and 89 FR 29451 (HD).

**Table RIA-2. No-action Fleet GHG Targets**
by model year and vehicle class,
as used in the economic modeling

| | Vehicle class | | |
|---|---|---|---|
| Model year | Light-duty | Medium | Heavy |
| 2027 | 170 | 461 | 103.4 |
| 2028 | 153 | 453 | 95.1 |
| 2029 | 136 | 408 | 91.0 |
| 2030 | 119 | 353 | 86.9 |
| 2031 | 102 | 314 | 74.4 |
| 2032- | 85 | 274 | 62 |
| Units: | g/mi | g/mi | g/ton-mile |
| | | | |
| Proposed action projection, MY 2032 | 250 | 614 | 117 |

Under the proposed action–that is, without the 2009 Endangerment Finding – the NHTSA will still regulate fuel economy, but recent legislation zeroed out the civil monetary penalty for noncompliance. The EPA invites comment on what to expect for vehicle fuel economy and GHG emissions in the coming years absent the 2009 Endangerment Finding. The proposed action projection row of Table RIA-2 shows a scenario where the LD GHG-equivalent of the fuel economy standards return to the standards set in 2010 for MY 2016.[79] For MD and HD vehicles, the Appendix uses a scenario using the baseline of the 2011 rule (76 FR 57106), adjusted for technological progress.

## 2. Resource and opportunity costs of increasing the EV share

*F*(*B*,*X*) denotes a constant-returns quantity index for the industry, of the same type as the Bureau of Economic Analysis uses in its industry and national accounting. Especially, *F* reflects consumer preferences. In this way, purchases of EVs *B* and ICE vehicles *X* reflect derived demands by ultimate consumers seeking transportation, freedom, mobility, reliability, and other characteristics.[80] Depending on the GHG standard being considered, "the industry" refers to either new LD, MD, or HD vehicles.

[79] 75 FR 25324 (May 7, 2010) "Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards; Final Rule" https://www.govinfo.gov/content/pkg/FR-2010-05-07/pdf/2010-8159.pdf.

[80] The economics of derived demand was developed by Alfred Marshall in *Principles of Economics*, MacMillan and Co., 1895 (https://eet.pixel-online.org/files/etranslation/original/Marshall,%20Principles%20of%20Economics.pdf) and Sir John Hicks' *The Theory of Wages*, MacMillan and Co., 1932 (https://archive.org/details/in.ernet.dli.2015.264357). Its real-world applications have proliferated since then, as with Gary S. Becker's, "A theory of the allocation of time", *Economic Journal*, 1965, and the Council of Economic Adviser's *Economic Report of the President*, 2019 (https://www.govinfo.gov/content/pkg/ERP-2019/pdf/ERP-2019-chapter7.pdf).

The elasticity of substitution quantifies how easy it is to induce the industry's consumers to switch between *B* and *X*. If the market views *B* and *X* as poor substitutes, then the elasticity of substitution in *F* is low, regardless of whether regulators think that EVs are just as good or better for owners than ICE vehicles. In that case, EVs will need to sell for a steep discount, and ICE vehicles for a substantial premium, in order for consumers to make purchases that align with the GHG standards at a market level. The close substitution case is represented with a high elasticity of substitution, in which case consumers readily switch from ICE vehicles to EVs with little relative price change.

Although this Appendix does not treat the elasticity of substitution as a constant, the elasticity can be understood as a parameter that allows consideration of scenarios corresponding to various assumptions about the ease of consumer substitution. Using market signals to assess which scenario is more realistic is known as revealed preference. As emphasized in OMB guidance for RIAs, revealed preference is an important component of reliable benefit-cost analysis. Figure RIA-1 is in the spirit of revealed preference analysis, as is what follows.

The "supply" of *F* reflects the marginal costs of producing the two vehicle types. Regulatory distortions increase this marginal cost, which this Appendix assumes is passed through one-for-one to the purchasers of vehicles.[81] Because *F* is a quantity index representing consumer preferences, regulatory-induced shifts reflect both added manufacturing costs and added opportunity costs of a fleet composition *B/X* that differs from what consumers desire. The costs increase, and are convex (i.e., increase at an increasing rate), as *B/X* increases above the desired level. The rate of increase is greater (less) when *B* and *X* are poor (close) substitutes, which is why CEA and Figure RIA-1 consult actual results of emission standards to gauge the ease of substitution. The level curves of *F* and the role of its substitution rates are illustrated in Figure 3 of the CEA report.

Because there are one million grams in a metric ton, the fleet miles-per-ton (*MPT*) equivalent of the fleet standard *G* is *MPT* = 1,000,000/*G*. From the equality version of the regulatory constraint (2), the ratio *B/X* is linear in fleet miles per ton of $CO_2$:

$$\frac{B}{X} = \frac{g}{G} - 1 = \frac{g}{1000000} MPT - 1 \quad (3)$$

The average cost per quality-adjusted vehicle is the cost of producing one unit of *F*(*B*,*X*). There is exactly one EV share, and therefore one ratio *B/X* and one fleet *MPT*, that minimizes this average cost.[82] The average cost of producing a unit of *F*(*B*,*X*) represents a quality-adjusted price increase in the sense that *F*(*B*,*X*) is more expensive to produce when consumers are not free to choose the mix of vehicles that they want.

We let $MPT_0$ denote the average-cost-minimizing fleet *MPT*. On a per-vehicle basis, the resource and opportunity costs associated with fleet compositions that differ from what consumers want is

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[81] Earlier EPA analyses of effects of vehicle regulation on retail prices (e.g., 2016 and 2020) also assumes a one-for-one pass through.

[82] CEA refers to miles per gallon (*MPG*) rather *MPT*. The two are strictly proportional with the factor 1,000,000/8,887. Council of Economic Advisers. (2020). Estimating the Value of Deregulating Automobile Manufacturing Using Market Prices for Emissions Credits:https://trumpwhitehouse.archives.gov/wp-content/uploads/2020/12/CEA_SAFE_Report.pdf.

the difference between the average cost under regulation and the average cost that would be achieved at $MPT_0$.[83] $F$ itself is a quality-adjusted quantity in that, when $MPT > MPT_0$, replacing $X$ sales with $B$ sales reduces $F$ even though it has no effect on the raw number of vehicles.

At fleet standards exceed $MPT_0$, average cost increases with $MPT$ at an increasing rate.[84] This essential result already points to two reasons why the 2024 vehicle rulemakings have enormous resource and opportunity costs. The first reason is that earlier LD rules moved fleet $MPT$ only 1,100 or so (that is, adding about 10 MPG), whereas the 2024 vehicle rulemaking would add another 5,600 (that is, another 50 MPG) to reach 11,765 miles per ton of $CO_2$.[85] The second reason is that the move from 10,765 MPT to 11,765 MPT costs more than moving from 9,765 to 10,765 MPT, which costs more than moving from 8,765 to 9,765 MPT (each of these is an increment of 1000 MPT), etc.

This economics of costs points toward three approaches to quantifying the resource and opportunity costs of GHG standards. One approach, taken in Section 2.1 for LD vehicles, estimates a lower bound by taking an estimate of the cost of earlier GHG standards and extrapolating it to the cost of the 2024 LMDV standards by the principle that costs increase at an increasing rate. The second approach, taken in Section 2.2 for LD vehicles, uses market information to assess how quickly the effect of $MPT$ on average cost increases with $MPT$. That section ties the rate of increase with the elasticity of substitution. A third approach, applied in Section 2.4 to MD and HD vehicles, is a special case of the first one that has sharper predictions when an estimate of the value of $MPT_0$ is available. All three approaches allow for the possibility that consumers may not see EVs and ICE vehicles as close substitutes.

### *2.1. EPA's 2021 light-duty rule already pointed toward enormous costs of a 50 percent EV fleet*

The purpose here is to obtain a lower bound on the resource and opportunity costs of GHG emissions for LD vehicles without relying on CEA's measurement of inter-manufacturer credits or relying on linear extrapolation. It is alternative to what follows in Section 2.2 and is the source of the bottom end ($114 billion annually) scenario for opportunity and resource costs of vehicle composition shown in Table RIA-1.

Table RIA-3 displays the LD emissions targets for the 2012 rule, the SAFE rule, the 2021 rule, and the 2024 LMDV rule for model year 2032. Each is expressed in terms of miles per ton of $CO_2$. The final column of the table's top panel compares each to the SAFE rule.

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[83] The impact of one regulation relative to a baseline of another regulation is the difference between the corresponding two average costs.
[84] This result is known as convex deadweight costs, which is a widely recognized principle in economics. Strictly speaking, the deadweight costs need not be convex at miles per ton far away from $MPT_0$. This possibility is discussed further in Section 2.2.
[85] The 2021 rule's target for fleet grams of $CO_2$ per mile was 161 (86 FR 74440), which corresponds to 55.2 MPG and 6,211 MPT. The 2024 vehicle rulemaking's target was 85 grams per mile (89 FR 27854), which corresponds to 104.6 MPG and 11,765 MPT.

**Table RIA-3. Light-duty emissions standards under four EPA rules**

| EPA rule | miles per $CO_2$ ton | Compared to SAFE |
|---|---|---|
| 2012 | 5,952 | 977 |
| SAFE | 4,975 | 0 |
| 2021 | 6,211 | 1,236 |
| 2024 | 11,765 | 6,790 |
| | | |
| 2024 as multiple of: | | |
| 2012 | | 6.9 |
| 2021 | | 5.5 |

Because per-vehicle costs are convex in tons per mile, an estimate of the per-vehicle costs of any one of the actions bounds the costs of each of the other three. The bottom half of the table begins to show how, using the SAFE rule as a baseline, the costs of the 2024 LMDV rule are bounded by the costs of the 2012 and 2021 rules.

Relative to the SAFE rule, the 2021 rule would have required a LD vehicle at the standard to drive an additional 1,236 miles on the amount of fuel that emits a ton of $CO_2$ upon combustion in the vehicle. The 2024 LMDV rule would require 6,790 miles beyond a vehicle at the SAFE-rule standard. In this dimension, the 2024 LMDV rule tightened standards 5.5 times more than the 2021 rule. If the compliance costs were convex in the amount that standards are tightened, then compliance with the 2024 LMDV rule would cost more than 5.5 times what 2021 rule did, which the EPA estimated to be $1,154 per vehicle in constant 2022 dollars.[86] In other words, relative to the SAFE rule, the 2024 LMDV rule would cost at least $6,338 per vehicle (up to rounding, 6338 = 1154*6970/1236). Because this is (a) a lower bound and (b) the lowest cost estimate for the 2024 LMDV rule among the methods considered in this Appendix, the $6,338 is the basis for this Appendix's "low-cost" scenario.

The $6,338 is interpolated for the transition years 2027-2031 according to the proportion of full MPT change (6,970) that had been phased in as of that year. In MY 2027, for example, Table RIA-2 indicates a standard of 170 grams per mile, which corresponds to 5,882 MPT, or an increase of 907 from the SAFE rule alternative of 4,975. Because that 907 is only 13 percent of the way to the MY 2032 MPT, the per-vehicle cost is assumed to be only 13 percent of the $6,338, which is $847 per vehicle. Each MY's per-vehicle costs are translated into vehicle quantities and opportunity-cost amounts using the same formulae as for the other approaches; see Section 3.

### *2.2 Evidence from the market for compliance credits*

The second approach to LD vehicles seeks a point estimate for per-vehicle resource and opportunity costs, rather than a lower bound. Specifically, it uses market information to assess how quickly the effect of *MPT* on average cost increases with *MPT*.

[86] The EPA reported $1,000 in 2018 dollars (86 FR 74492), which is equivalent to $1,154 in 2022 dollars.

The costs of increasing miles per ton (equivalently, the EV share) beyond $MPT_0$ can be quantified algebraically as the quadratic formula (4):[87]

$$\text{impact of } MPT \text{ on per-vehicle cost} \equiv \Delta(MPT) = \frac{k_0}{2\sigma_0}(MPT - MPT_0)^2 \tag{4}$$

where $k_0$ is a constant that depends only on the unregulated outcome and $\sigma_0$ is the elasticity of substitution between vehicle types in the quantity index *F* at the unregulated EV share.

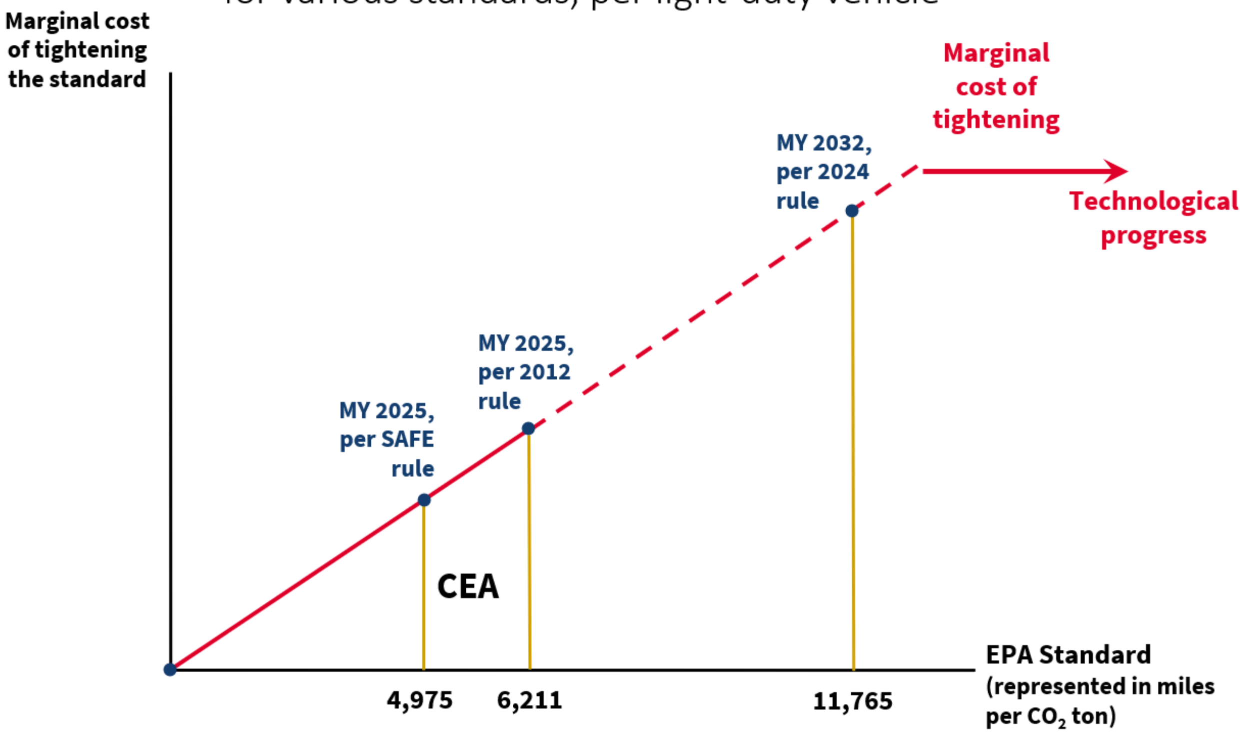
Because formula (4) is inversely proportional to the elasticity of substitution, it formalizes this Appendix's qualitative conclusion about the ease of substitution between vehicles. If the market views *B* and *X* as poor substitutes, then $\sigma_0$ is low, and the standard *MPT* has a large effect on per-vehicle cost, especially to the extent it departs from what consumers want (represented as $MPT_0$). A fundamental omission from the EPA's 2021 and 2024 vehicle rulemakings was any attempt to assess the degree of substitution.

Equation (4) readily allows for technological progress in vehicle manufacturing by letting $MPT_0$ increase with time at the same rate under the proposed rule and with no action. This progress may represent changing consumer preferences within the ICE category such as the increased adoption of (non-plug-in) hybrid vehicles. It may represent engineering advances, changes in consumer attitudes or circumstances related to EVs, or trends in the structure of energy prices. All of the benefit-cost scenarios from the revealed-preference approach assume technological progress in this way, with details explained further in section 2.6.

The *MPT* derivative of equation (4) is illustrated by Figure RIA-3 red line, adapted from CEA. The cost impact shown in equation (4) therefore corresponds to areas in the figure. The red arrow indicates the assumed technological progress that shifts the red line horizontally over time. Three standards are shown as points on the red line.

[87] This is a second-order Taylor approximation to the impact on average cost per quality-adjusted vehicle in the neighborhood of no standard ($MPT_0$). CEA (2020, footnote 16, https://trumpwhitehouse.archives.gov/wp-content/uploads/2020/12/CEA_SAFE_Report.pdf) found that a quantity index *F* with a constant elasticity of substitution would be closely approximated by the quadratic equation (4), except when the standard is especially tight, in which case quadratic underestimates compliance costs. Especially tight standards are also analyzed in this DRIA, particularly for trucks. Note that an assumption like equation (4) is required to extrapolate a point estimate, but not for estimating a lower bound as in Section 2.1.

Figure RIA-3. Opportunity and Resource Costs
for various standards, per light-duty vehicle




The 2020 study by CEA estimated the slope and intercept of the red line by measuring the price at which automakers buy and sell credits. For a manufacturer whose sales is relatively intensive in ICE vehicles, the credit price is its cost of meeting the standards. The same credit price reflects the opportunity cost of selling an ICE vehicle for a manufacturer that sells credits because the ICE sale would reduce its credit revenue. CEA relied on data public records of nearly $700 million in credit transactions, which they used to measure how much the credit price increased as the EPA cut the emissions target over time.[88]

In effect, CEA measured the ease of market substitution between EVs and ICE vehicles. If consumers would readily switch from ICE vehicles to EVs, then the regulatory credit prices would hardly increase with the standard because manufacturers would be increasing the EV intensity of their sales with little consumer resistance. CEA found the opposite: tighter standards were associated with substantially greater regulatory-credit prices.

Part of the red line is dashed because it is beyond the range of standards that CEA considered. It was particularly focused on the range between 4,975 (SAFE rule) and 6,135 miles per ton of $CO_2$ (the 2012 rule that SAFE would replace), as well as historical standards that were less stringent

[88] CEA (2020) also considered the possibility that inter-manufacturer credit markets are not competitive in the sense that manufacturers might withhold some of their trading to favorably affect the credit market price, driving a wedge between their marginal cost of compliance and the credit price. CEA notes that the average automaker is neither a net buyer nor seller over time, so the market credit price generally reflects the sales-weighted average marginal cost of compliance even if the two are not equal at a manufacturer level. The credit price may be a conservative estimate of the marginal cost of compliance if larger manufacturers tend to be net buyers. https://trumpwhitehouse.archives.gov/wp-content/uploads/2020/12/CEA_SAFE_Report.pdf

than the SAFE rule. As already noted, any benefit-cost method must engage in extrapolation because the 2024 LMDV rule set standards so far outside the U.S. experience.

What follows draws more precisely from the CEA cost model, including allowing for standards to vary by MY. It also allows for technological progress in vehicle manufacturing and other modeling approaches. Nevertheless, the few arithmetic steps illustrated in Table RIA-3 indicate why the costs to vehicle consumers of the 2024 LMDV rule must exceed $100 billion annually and likely near $300 billion.

Table RIA-3 shows that the 2024 LMDV rule tightened standards 6.9 times more than the 2012 rule would have. If the compliance costs were convex in the amount that standards are tightened, then compliance with the 2024 LMDV rule would cost more than 6.9 times what 2012 rule did, which CEA estimated to be $2,538 per vehicle (converted to 2022 dollars). If a standard adding less than 1,000 extra miles cost $2,538, then presumably a standard adding 6,790 would cost at least 6.9 times as much, and potentially much more if costs were convex in miles per ton. This points to a cost of at least $18,000 per vehicle. If that were applied to 15 million new vehicles annually, that is at least $270 billion annually relative to the SAFE rule.

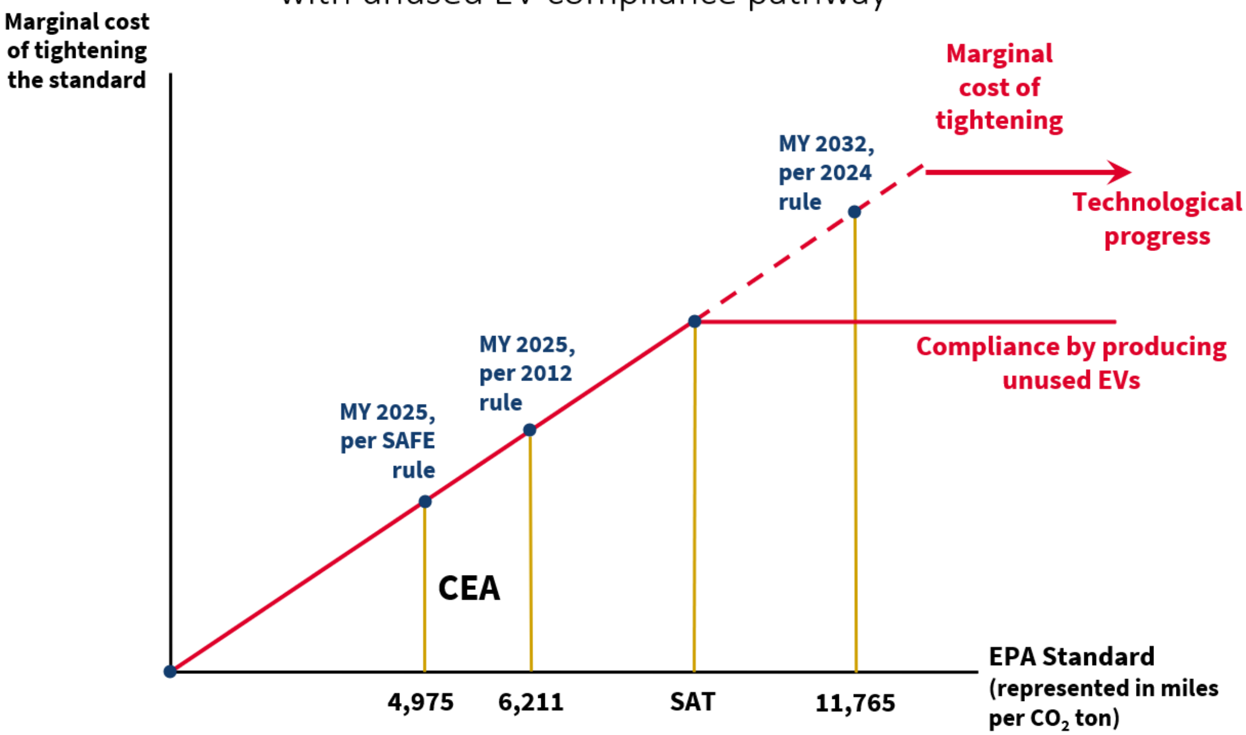
### *2.3 EV Consumer Satiation*

CEA assumed that compliance with the standard is a combination of ICE-manufacturing changes, changes in consumer choices among ICE vehicles, and price-induced decisions of vehicle buyers to select EVs rather than ICE vehicles. In doing so, it warned that the marginal-cost schedule shown in Figure RIA-3 would turn sharply upward near standards that were “especially tight.” At that point, none of the three pathways considered by CEA would be economical.

However, a fourth pathway is possible: to manufacture EVs that do not replace ICE vehicles but are sold very cheaply to buyers who hardly intend to use them. At the extreme, EVs may be given away or even sold at a negative price to compensate for storage, in order to give the manufacturer room to sell the ICE vehicles that consumers really want. Or maybe manufacturers develop a compliance vehicle that they expect consumers to rarely use, but instead obtain it for parts or repurpose the batteries. The cost of producing the “free,” “compliance,” or “scrap,” EVs would be built into the price of ICE vehicles. This pathway is itself expensive, but makes any standard achievable because its marginal cost does not rise with *MPT*. As discussed in Section 2.4 and 2.5, it may be the only pathway that 50-percent-EV targets would be reach in truck markets in the near future.

Figure RIA-4 adds the fourth compliance pathway to Figure RIA-3. It adds a horizontal (constant) marginal cost at a high level. The amount of that constant marginal cost has nothing to do with consumer preferences; it is just a function of the cost of producing EVs. It dominates the other three compliance pathways when the standard exceeds SAT (“satiation”). Figure RIA-4 is only for illustration and is not used to produce quantitative estimates for the LD market. The EPA seeks comment on how regulated-manufacturer strategies might have evolved if the 2024 vehicle rulemakings had continued.

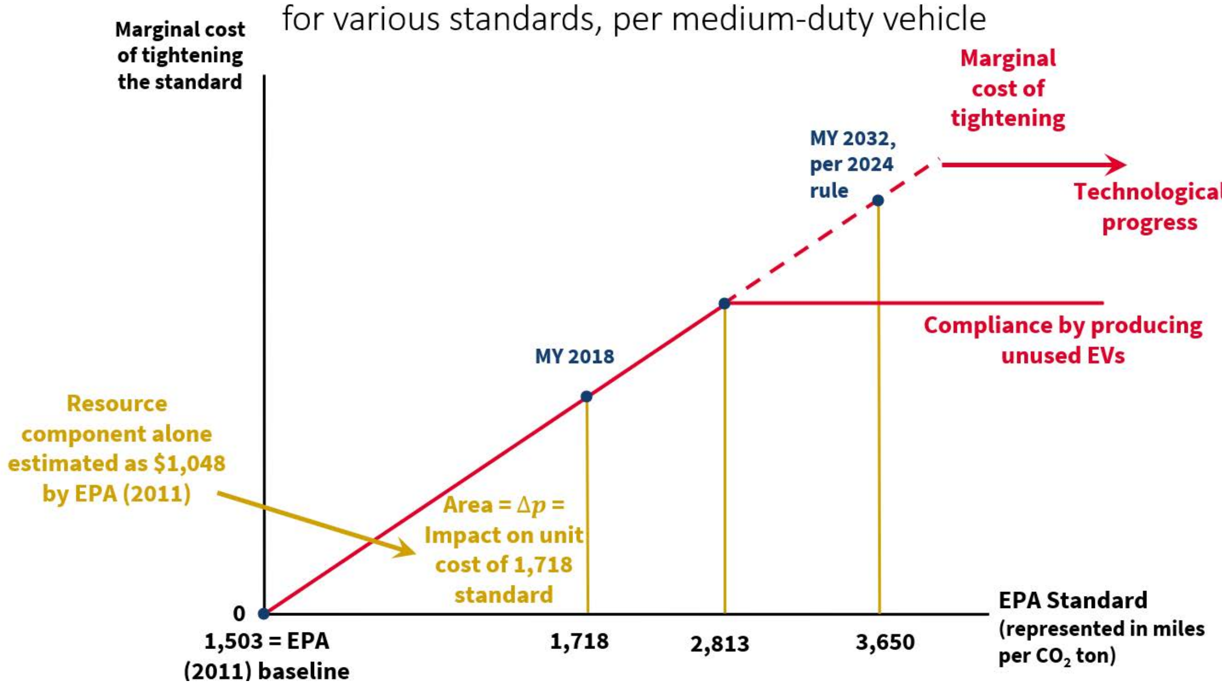
Figure RIA-4. Opportunity and Resource Costs
with unused EV compliance pathway




*2.4 Costs of Medium-duty standards*

Equations (3) and (4) can describe MD and HD standards too, albeit with different parameters. Unlike LD vehicles, these vehicles were not subject to long-standing fuel-economy standards prior to the 2009 Endangerment Finding. Furthermore, those fuel economy standards are from a different statute with different provisions for relaxing fuel economy requirements. In terms of the notation from equation (4), $MPT_0$ for MD vehicles can be taken as the fleet average miles per ton of $CO_2$ in the baseline of the 2011 rule (76 FR 57106), adjusted for technological progress since then. This pins down the *MPT* intercept in Figure RIA-5.

Figure RIA-5. Opportunity and Resource Costs
for various standards, per medium-duty vehicle




Although CEA did not examine credit trades between manufacturers of MD and HD, Figure RIA-5 shows how the marginal-cost slope can be estimated from the EPA's 2011 findings. From a baseline of no-GHG or fuel-economy standards for MD vehicles, the EPA projected (in 2011) that its 2011 rule would add $1,048 to the average cost of a MY 2018 vehicle through vehicle technology costs along (a resource cost). That corresponds to the triangular area in Figure RIA-5. The base of the triangle is between the two emissions levels: 1,503 (baseline) and 1,718 miles per ton of $CO_2$. That is enough information to pin down the entire marginal cost line (red) in the figure.

For legibility purposes, Figure RIA-5 is not drawn to scale. If it were, the *MPT* values of 2,813 and 3,650 would be far out to the right and the height of the line well above what it would cost to comply with the year 2032 standard by purchasing MD vehicles and parking them, just to have room to sell the ICE vehicles that consumers would want.[89] We estimate that this pathway dominates for standards above 2,813 *MPT*, such as the standard set by the 2024 vehicle rulemaking.

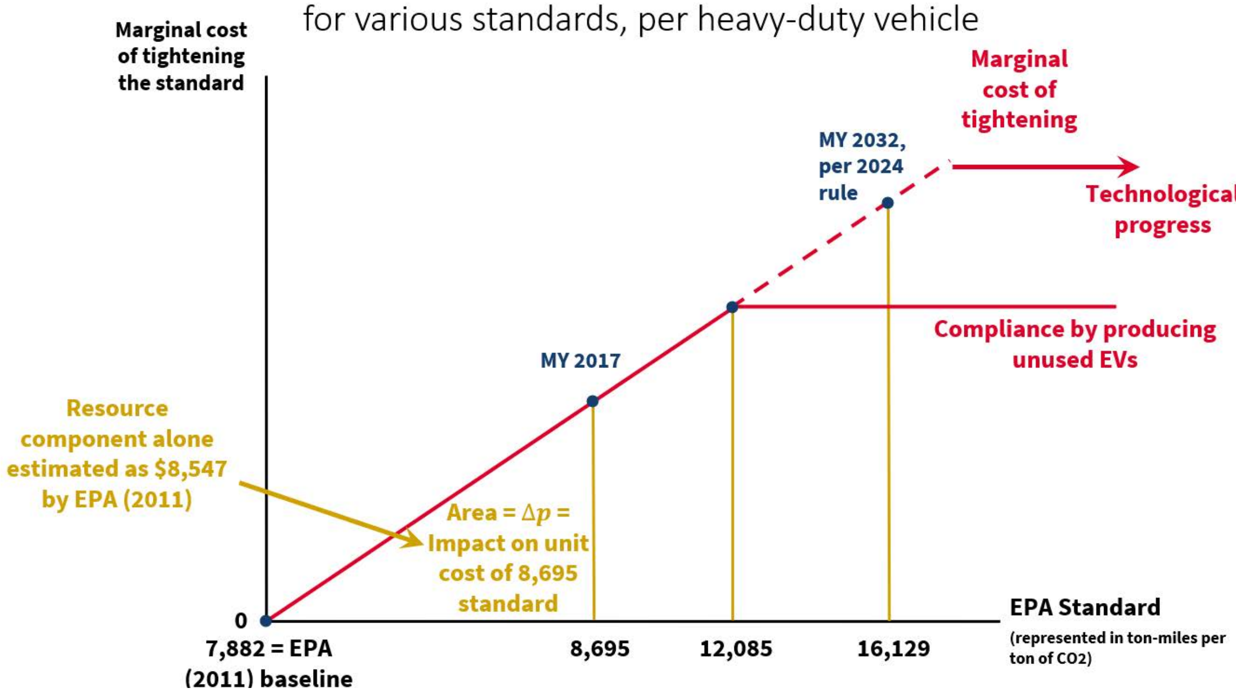
### *2.5 Costs of Heavy-duty standards*

Figure RIA-6 shows the analogous chart for the HD market, except that standards are expressed in freight ton-miles per metric ton of $CO_2$ emitted. Extrapolating the 2011 rule's estimates (76 FR 57321, converted to 2022 dollars) to the 2024 vehicle rulemaking's target emissions for HD vehicles results in "triangle" costs exceeding the cost of a new HD EV. As Figure RIA-5 does, Figure RIA-6 therefore shows a more economical "unused EV" production compliance pathway beginning at a standard of 12,085 freight-ton miles per ton of $CO_2$. The 2024 vehicle rulemaking's target for the EV

[89] To put it another way, the near-50 percent EV share target (MY 2032) for MD-vehicles is more than twenty times what the EV share was when the rule was finalized.

share of new HD trucks (89 FR 29440) is also near 50 percent and as such even further outside the range of historical experience than the MD target. As an example of the amount of ambition in the 2024 vehicle rulemaking, its standards were expected to move the EV share of new sleeper-cab tractors–among the heaviest vehicles regulated by the EPA–from zero to 25 percent in a mere three years. Recall from Figure RIA-1 that, in percentage points, that change would be more than triple the fastest three-year change ever experienced by the much lighter LD vehicles.

Figure RIA-6. Opportunity and Resource Costs for various standards, per heavy-duty vehicle




*2.6 Model-year specific costs*

For each MY 2027-2055 and vehicle-class-scenario, the corresponding per-vehicle combined opportunity and resource cost of the proposed rule is calculated from that year's no-action standard and projected miles (or ton-miles) per ton of $CO_2$ under the proposed rule as shown in Table RIA-2. The method used in each case is summarized in the following Table.

**Table RIA-4. Cost-per-vehicle methods by vehicle class and scenario**

| Vehicle class | Data source | Method |
|---|---|---|
| Light-duty | EPA 2021 | Table RIA-3 plus technological change |
| Light-duty | Market | Figure RIA-3 plus technological change |
| Medium-duty | EPA 2011 | Figure RIA-5 plus technological change |
| Heavy-duty | EPA 2011 | Figure RIA-6 plus technological change |

To estimate a rate of technological progress in LD vehicles, we used our automotive trends data for MY 1978 through 2011, before GHG standards were imposed. When real-world MPG was regressed on year and horsepower, the coefficient on year was 0.553. When weight was added to the regression, the year coefficient was 0.133. Except for sensitivity analysis, the annual rate of progress is taken to be the average of these two, 0.343. It is converted to miles per ton by multiplying by the factor 1,000,000/8,887.

With technological progress modeled in this way, eventually even a strict standard has no cost. Arithmetically, $MPT_0$ eventually catches up with the MPT-equivalent of target set for the out years by the 2024 vehicle rulemakings. The rate of technological progress for MD vehicles, and the rate for HD vehicles, are each set so that the year of zero cost is the same as it is for LD vehicles.

The average-cost impact of the no-action target $MPT_{no\text{-}action}$ relative to the $MPT_{proposed}$ that would prevail under the proposed rule is $\Delta(MPT_{no\text{-}action})$ - $\Delta(MPT_{proposed})$. Because Table RIA-2's bottom row for MD and HD vehicles corresponds to $\Delta(MPT_{proposed}) = 0$, without technological progress these vehicle classes have:

$$\Delta(MPT_{no-action}) - \Delta\big(MPT_{proposed}\big) = \Delta(MPT_{2018})\left(\frac{MPT_{no-action} - MPT_0}{MPT_{2018} - MPT_0}\right)^2 \qquad (5)$$

where and $MPT_{2018}$ and $\Delta(MPT_{2018})$ are the 2018 standard and the EPA per-vehicle cost finding in its 2011 MHDV RIA, respectively, indicated in Figure RIA-5 or RIA-6, depending on the vehicle class. With technological progress, the *MPT* intercept in equation (5)'s numerator is incremented by the amount of technological progress assumed to have occurred between 2018 (2017 for HD, as indicated in the figure) and the MY for which impact is being estimated.

Take, for example, MY 2027 MD vehicles. From Table RIA-2, the no-action *MPT* is 1,000,000/461 = 2,169. From Figure RIA-5, $MPT_{2018}$, $MPT_0$, and $\Delta(MPT_{2018})$ are 1,718, 1,503, and \$1,048, respectively. The *MPT* intercept for the numerator of (5) is augmented by 81 for technological progress since 2018. Therefore, the deviations in the numerator and denominators are 585 and 215, respectively. When rescaled by the square of the ratio of these two deviations, the 2011 rule's per-vehicle cost of \$1,048 shown in the figure becomes \$7,782 for the no-action outcome.

## 3. Vehicle quantities and opportunity costs of reduced vehicle sales

### *3.1 The price elasticity of vehicle demand*

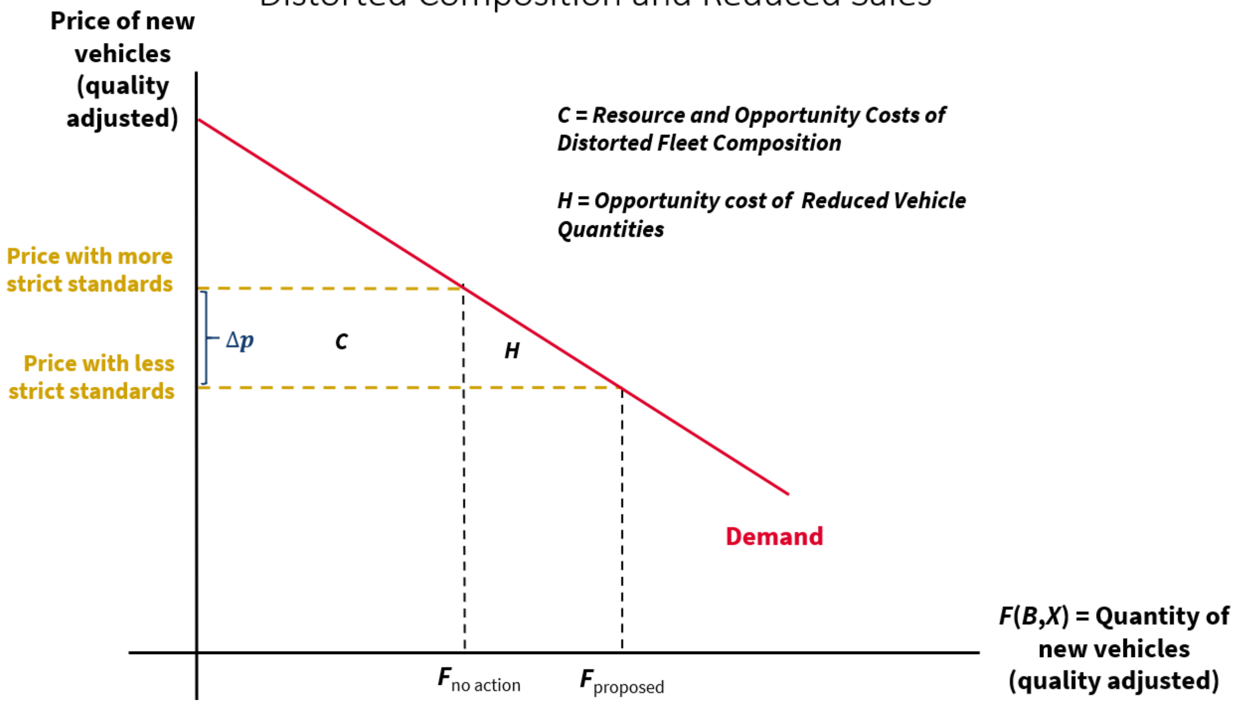
When regulations add to vehicle costs, consumers will purchase fewer vehicles, at least as measured by the quantity index. To quantify this effect, we add a market demand curve to the analysis. Specifically, let $D(F)$ denote the inverse market demand for $F$. This pins down the equilibrium value of the quantity index $F$ and the price $P$ of a unit of $F$. Namely, price is related to the quantity index by the demand equation $P = D(F)$, which also equals the marginal cost of supplying $F$.[90]

Figure RIA-7 illustrates. The resource and opportunity costs savings from the proposed rule for vehicle buyers are equal to the combined area *C* and *H*. The rectangular area *C* by itself represents

[90] Adding constant seller markups between marginal cost and *F* would further add to the opportunity costs calculated here. The EPA invites comment on whether and how to include markups.

the resource and opportunity costs of distorted vehicle composition. The height of the rectangle is the quality-adjusted price impact calculated with the methods listed in Table RIA-4. In principle, the price impact is applied to the no-action quantity. However, lacking data on the price and quantity without action, we (a) express the price impact as a ratio to the average vehicle price measured in 2025, which is somewhere in between the no-action price and the price that would prevail under the 2024 vehicle rulemaking; (b) multiply the proportionate impact by the corresponding demand factor $F_{no\text{-}action}/F_{proposed}$; and (c) multiply by 2024 revenue for the vehicle class.[91]

Figure RIA-7. Resource and Opportunity Costs
Distorted Composition and Reduced Sales




Regulations that reduce the quantity index have an additional opportunity cost measured as the usual Harberger triangle B in the market diagram having *F* on the horizontal axis and *P* on the vertical axis. The EPA continues to assume that the market-level price elasticity of vehicle demand is -0.4 for LD vehicles. When demand has price elasticity equal to the constant $\eta < 0$, the opportunity cost area H is no greater than vehicle-class revenue times $\frac{\left(\frac{P_{no\ action}}{P_{proposed}}\right)^{1+\eta}-1}{1+\eta}$. The assumed price elasticity for MD and HD is -1, which is in the range of price elasticities used by the EPA in the past.

For example, when LD costs are sourced from the EPA (2021, 86 FR 744, 86 FR 7440), the MY 2032 cost is $6,338 (recall section 2.1), which is at least 13 percent of what the average transaction price would be under the proposed rule. With a price elasticity of -0.4, that translates into a quantity reduction of five percent. The area C is thereby 12.4 percent of revenue under the proposed rule,

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[91] As long as the demand for vehicles is price inelastic, this calculus slightly underestimates the dollar amount represented by the area *C* in Figure RIA-7.

and the area H another 0.3 percent. Because that revenue a bit less than revenue in recent years ($765 billion), a slightly conservative estimate of the combined area C+H is $97 billion annually. C+H is less for the years 2027-2031 due to the less stringent standards in those years.

### *3.2 Vehicle cost categories by model year*

Dollar values for the areas *C* (vehicle composition) and *H* (vehicle quantity) are calculated for each vehicle class, scenario, and MY 2027-2055. MYs are combined using either a three or seven percent annual discount rate. The class/scenario summary is either an annualized value for the years 2027-2055 or a net present value from the perspective of the year 2025. These results are shown in the upper rows of Table RIA-5.

**Table RIA-5. Benefits and Costs of Eliminating Vehicle GHG Standards**

billions of 2022 dollars, annualized over years 2027-2055

| | Scenarios | | | |
|---|---|---|---|---|
| Scenario name: | EPA3 | Market3 | EPA7 | Market7 |
| Discount %/yr: | 3% | 3% | 7% | 7% |
| LD Cost Source: | EPA | Market | EPA | Market |
| **Benefits** | | | | |
| Opportunity (consumer surplus) and resource cost savings | | | | |
| Vehicle composition | | | | |
| Light-duty | 81 | 324 | 75 | 302 |
| Medium-duty | 9 | 9 | 9 | 9 |
| Heavy-duty | 32 | 32 | 30 | 30 |
| Vehicle quantity | 17 | 44 | 18 | 42 |
| Strained electric grid | 17 | 21 | 10 | 13 |
| Savings on Insurance | 2 | 2 | 2 | 2 |
| Savings on EVSE Ports | 14 | 14 | 14 | 14 |
| Benefit Total | 171 | 444 | 157 | 411 |
| **Costs** | | | | |
| Increased congestion | 1 | 1 | 1 | 1 |
| Fossil-fuel risk | 2 | 1 | 2 | 1 |
| PM emissions | 4 | 3 | 3 | 2 |
| Costs Total | 8 | 5 | 7 | 5 |
| **NET BENEFITS** | | | | |
| **Annualized 2027-2055** | **164** | **439** | **150** | **406** |
| **NPV to 2025** | **3,051** | **8,184** | **1,722** | **4,664** |

As expected, the proposed rule is expected to have annualized benefits in the hundreds of billions of dollars for buyers of new LD vehicles. Although small in comparison to the LD benefits, the benefits for buyers of new MD and HD vehicles are substantial, ranging from $9 billion to $32 billion annually, depending on the scenario and class.

### 4. Opportunity costs of a strained electric grid

EV charging can soak up spare generation and transmission capacity that would otherwise power everything from factories to data-center servers to air-conditioning on the hottest days. At a time when only about five percent of California's registered vehicles were electric, state officials urged residents to "avoid … charging electric vehicles" because "California and the West are expecting extreme heat that is likely to strain the grid."[92] The 2024 vehicle rulemaking aimed for 50 percent EVs nationwide, or about ten times the California grid burden. Additional grid burden would come from electrifying MD and HD vehicles.

The 2021 and 2024 vehicle rulemakings quantified such opportunity costs by assuming that the rules would have little effect on electricity prices or average costs. In contrast, Fitzgerald and Mulligan (2023) modeled EV charging in the face of renewable energy standards and EPA emission standards for LD vehicles. They assumed that essentially all LD vehicles would become electric, which is more ambitious than the EPA's 2024 target. However, they did not consider any additional electricity demand from the more energy intensive MD and HD vehicles that would also be about half electric under the 2024 vehicle rulemakings.

The Fitzgerald and Mulligan approach assumes that supply meets demand and is allocated to the highest-value uses. The cost of electrifying vehicles would be even greater if it led to blackouts or misallocation of the available supply. With these caveats, this Appendix uses the Fitzgerald and Mulligan estimates.

The green curve in Figure RIA-2 represents the supply of electricity generated from renewables. The black curve is the supply of fossil-fuel generated electricity, shown as a mirror so that movements to the right in Figure RIA-2 represent a substitution on the supply side from fossil-fuel generation to renewable energy. The point *a* indicates the quantity and wholesale price of electricity produced from renewable sources under the proposed rule, assuming that the Biden administration's 80 percent renewable goal is realized. The point *b* corresponds to fossil-fuel produced electricity under the proposed rule. The points *c* and *d* are their analogues under the baseline of the 2024 vehicle rulemakings.[93] Together, they involve 1 TWh more electricity usage than under the proposed rule.

Figure RIA-2's combined areas *A*, *B*, and *C* measure the proposed rule's annual savings of resources for generating electricity. Part of this savings is already counted in consumer surplus, which reflects the choices of consumers who considered vehicles options at a time when the wholesale price of electricity was about $50 per MWh. The additional cost of $57 per MWh would

[92] California ISO. (August 30, 2022). "Excessive heat starting tomorrow will stress energy grid" https://www.caiso.com/Documents/excessive-heat-starting-tomorrow-will-stress-energy-grid.pdf.
[93] The heights of *a*, *b*, *c*, and *d* are, in dollars per MWh, 117, 29, 136, and 30. See Fitzgerald, T. and Mulligan, C.B. (2023). The Economic Opportunity Cost of Green Recovery Plans, Table 2.

either require government subsidies, or be passed onto consumers.[94] In aggregate, the additional cost shown in Figure RIA-2 would amount to $57 billion annually. We assume that one-third is associated with HD vehicles and the other two-thirds to LD and MD.

To the extent that the quantity of EVs increases even without regulatory incentives, or the EV share of the stock has yet to catch up to the EV share of new sales, only part of the $57 billion applies. For each MY and vehicle class, the full amount is rescaled by the ratio the impact of the rule on the EV share to the change in the EV share from the year 2025 that is required to meet the year 2032 standards. The annualized cost savings, combined across vehicle classes, ranges from $10 billion to $21 billion, depending on the discount rate and compliance scenarios. See Table RIA-5.

## 5. Market-equilibrium emissions

U.S. vehicles are not, and will not be, the only source of GHG and particulate emissions. It is therefore essential to anticipate the effect of vehicle regulations on other emission sources. The 2024 vehicle rulemaking recognized vehicle-market emissions substitution in the form of shifts toward EVs that increase the demand for fossil fuels by the electricity-generation sector. However, another source of substitution in the vehicle market is changes in the intensity of use. As the 2024 vehicle rulemakings would, by design, create a shortage of ICE vehicles and a surplus of EVs, per-vehicle utilization of ICE vehicles would increase while utilization of EVs would fall. Eliminating GHG standards for vehicles would have the opposite effect.

Substitution will also occur in fossil-fuel markets. Vehicle regulation shifts one component of fossil-fuel demand, which unmistakably spills over onto supply and other elements of fossil-fuel demand.

### *5.1. The Vehicle Inventory*

Whereas the opportunity and resource costs of regulating vehicle manufacturer are primarily linked to each cohort of new vehicles, emissions effects depend on the Nation's entire inventory of vehicles and their utilization. To translate changes in the composition and number of new vehicles into inventory composition and number, we begin with an observed age distribution separately for LD, MD, and HD vehicles.[95] An age distribution is considered as a vector. The impact of the proposed action on the number of ICE vehicles in the Nation's inventory is estimated as the dot product of the age distribution vector and the vector whose elements are the impact factor of the proposed action (ratio of proposed action to no-action) for number of new ICE vehicles each year in the past. For example, if six percent of the vehicles are less than one year old and the first year of the rule cut ICE vehicle sales in half, then the impact factor for the number of ICE vehicles in inventory would be estimated as 0.06*0.5 + (1-0.06)*1 = 0.97. Solely for the purposes of simulating

[94] In the latter case, the sale of EVs would encounter even more consumer resistance than already modeled in the vehicle-cost sections of this DRIA.
[95] https://nepis.epa.gov/Exe/ZyPDF.cgi/P100OXEO.PDF?Dockey=P100OXEO.PDF and Table 3.16 of https://tedb.ornl.gov/wp-content/uploads/2022/03/TEDB_Ed_40.pdf.

inventories and emissions, the new-vehicle share of EVs is assumed to never fall below nine percent for LD, two percent for MD, and one percent for HD vehicles.

### *5.2. Fossil-fuel market equilibrium*

Vehicle regulation shifts one component of fossil-fuel demand, which unmistakably spills over onto supply and other elements of fossil-fuel demand. This Appendix translates fleet emissions impacts into worldwide emissions using fossil-fuel supply and demand.

Worldwide fossil-fuel is the sum of demands for its various uses, one of which is powering vehicles in the U.S. The EPA vehicle standards potentially reduce the demand for fossil fuels to power U.S. vehicles. If the standards do not shift world supply or other components of world demand, then the equilibrium change in worldwide fossil-fuel use is between zero and the amount by which the EPA standards shift the demand coming from U.S. vehicles. Except in the one-for-one limiting case, reduced emissions from U.S. vehicles are at least partly offset by increased emissions from other uses due to a reduced world price of fossil fuels.[96]

By ignoring fossil-fuel market equilibrium, the 2021 and 2024 vehicle rulemakings implicitly assume the limiting one-for-one case. More realistically, if the worldwide supply and demand for fossil fuels are equally price elastic (or equally inelastic) but with opposite signs, then the equilibrium change in worldwide fossil-fuel use is half the shift from U.S. vehicles. This omission alone resulted in exaggerated emissions effects in the 2024 vehicle rulemakings. The EPA seeks comment on assessing the fossil-fuel market substitution effects resulting from U.S. GHG emissions standards.

### *5.3. Particulate emissions*

The impact of the proposed action on worldwide PM emissions ($PM_{2.5}$) is assumed to be proportional to its impact on GHG emissions. For the purposes of projecting U.S. health consequences of PM emissions, it matters whether where the emission changes. That is, part of the GHG emissions offset is not an offset for U.S. PM emissions because some of the change in fossil-fuel use is outside the U. S. The EPA seeks comment on quantifying this part. For the purposes of this Appendix, this Appendix assumes that all of the offset is outside the U.S., or in a part of the U.S. that does not affect U.S. health. This assumption serves to exaggerate the increase in particulate matter emissions that would result from this proposed action.

### *5.4. Utilization scenarios*

As the Nation's fleet of vehicles is pushed from the supply side to become more EV intensive, the lifetime utilization rate of EVs will fall. Earlier adopters of EVs tend to be more interested in driving them, as suggested by their willingness to pay the higher retail prices that prevail early in the market life cycle. For similar reasons, the lifetime utilization rate of ICE vehicles is expected to increase when new ICE vehicles become scarce. This Appendix models utilization responses with a function

[96] Due to the size of the worldwide market, an EPA emissions standard may have just a small effect on the world price, but that small price change applies to the much larger worldwide quantity.

*f*(*B*/*X*) that maps the ratio of EVs to ICE vehicles to the relative utilization rate of ICE vehicles.[97] In this notation, the 2021 and 2024 vehicle rulemakings' assumption of constant lifetime mileage ("Vehicle miles traveled") amounts to an assumption that *f* is inelastic to *B*/*X*.

ICE vehicle usage patterns leave plenty of room for increased utilization rates in response to regulatory incentives. Especially, vehicles are parked more than 90 percent of the time. Consumers can also spend resources extending the life of their ICE vehicles, including the ICE vehicles they purchase in MY 2027 and beyond. This Appendix assumes that the elasticity of the ICE-vehicle utilization rate, as a ratio to the EV utilization rate, has an elasticity of 0.3 with respect to the number of registered EVs per registered ICE vehicle. In other words, the utilization-rate changes occur, but not enough to fully offset the reduction in ICE quantities that result from GHG standards. Indeed, 0.3 is closer to no change than a full offset.

[97] Although the 2024 LDHD RIA discusses "vehicle scrappage" in connection with maintenance costs, its emissions simulations assume that vehicles sold during model years 2027 and later are driven an average of 195,264 regardless of the vehicle standard or powertrain. It assumes 225,865 miles for light trucks (p. 12-12).