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Comment on the Reconsideration of 2009 Endangerment Finding and Greenhouse Gas Vehicle Standards

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Environmental Protection Agency
1200 Pennsylvania Avenue NW
Washington, DC 20460
Attn: Docket ID No. EPA-HQ-OAR-2025-0194
Submitted via: **www.regulations.gov**

Dear Administrator Zeldin,

On behalf of Resources for the Future (RFF), I am pleased to share the accompanying comments to the Environmental Protection Agency (EPA) on the proposed *Reconsideration of 2009 Endangerment Finding and Greenhouse Gas Vehicle Standards*.

RFF is a nonpartisan, independent, nonprofit research institution in Washington, DC. Its mission is to improve environmental, energy, and natural resource decisions through impartial economic research and policy engagement. While RFF researchers are encouraged to offer their expertise to inform policy decisions, the views expressed here are those of the individual authors and may differ from those of other RFF experts, its officers, or its directors. RFF does not take positions on specific policy proposals.

Several RFF experts have provided comments on the proposed rule in two categories related to our research expertise. These are described in detail in the accompanying response and summarized here.

- **C-2**, regarding the scientific underpinnings of the Endangerment Finding.
  A preponderance of evidence since the 2009 finding confirms that greenhouse gas emissions significantly affect public health and welfare, and that the costs of emissions and their associated economic effects outweigh the benefits across a range of sectors.

- **C-21**, regarding analysis of the proposal's overarching costs and benefits.
  The draft regulatory impact analysis provided for the proposal misinterprets findings from past research, causing the proposal to overstate the net benefits of revoking vehicle emission standards. Several assumptions about manufacturer behavior and market outcomes, such as the relationship between compliance costs and regulatory stringency, remain unclear or unjustified in that analysis, causing the proposal's approach to depart from historical methods for estimating vehicle technology costs without explanation. Further, the proposal's analysis relies on obsolete data that are inconsistent with recent market information. RFF researchers' estimates are in line with previous EPA rule estimates.

Our comments focus on our areas of economic and policy expertise, and not the legal questions proposed; we acknowledge that our empirical work may be cited by others, as it has in the past.

If you have any questions or would like additional information, please contact Liam Burke at **lburke@rff.org**.

Sincerely,

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Resources for the Future

C-2 Comment

The proposal asserts that the scientific underpinnings of the Endangerment Finding are weaker than previously believed and not supported by the body of scholarship since 2009. NASEM (2025) provides the most recent review of the literature regarding greenhouse gas (GHG) emissions' effects on public health and welfare. The public effects covered in NASEM (2025) include local and regional exposures. A repeal of these findings has broad implications (Elkerbout 2025). The thorough review of the scientific literature provided in NASEM (2025), as well as the conclusions provided, stand in direct contrast to the EPA's proposal language and references.

In its proposal, the EPA cites the US Department of Energy's Climate Working Group (CWG) report extensively, titled "A Critical Review of Impacts of Greenhouse Gas Emissions on the US Climate" (CWG 2025), to support its scientific claims on the connections between greenhouse gas emissions and public health and welfare. NASEM (2025) demonstrates that this report is highly inaccurate in its assessment of the related literature. The proposal and CWG (2025) are also inaccurate with respect to stated assumptions and conclusions regarding economic impacts associated with the effects on human health and welfare. A significant body of peer-reviewed empirical work concludes that greenhouse gas emissions' effects on health and other societal costs outweigh the benefits from those emissions (NASEM 2017).

CWG (2025) incorrectly interprets several recent economic studies (Prest 2025). For example, the report incorrectly cites Newell, Prest, and Sexton (2025) when it claims that the net temperature effect on GDP "is likely positive but too uncertain to distinguish from zero." Newell, Prest, and Sexton (2025) find that the likelihood of a negative impact on GDP is 92 percent, or an 8 percent likelihood of a negative value. CWG (2025) also inaccurately characterizes contemporary literature regarding the social costs of carbon, omitting the latest peer-reviewed modeling and data which have helped the EPA revise its cost estimates upwards in the recent past (Rennert et al. 2021; EPA 2023). It also incorrectly operationalizes economic terms and misapplies equations to incorrect ends, including the marginal social benefits of gasoline (which the literature finds are smaller than the costs) and optimal gasoline tax (which would be larger than CWG (2025) concludes).

In short, a significant, additional body of literature since the 2009 finding has estimated the costs of emissions and found that the emissions' effects outweigh the societal benefits across a range of economic sectors, from agricultural productivity to real property valuation and hazard exposures (Kotz, Levermann, and Wenz 2022; Waidelich et al. 2024). Findings from this literature contradict the proposal's assertions about the scientific underpinnings of the Endangerment Finding.

C-21 Comment

The proposal asserts that the potentially resulting increase in price for vehicles from emissions regulation disincentivizes consumers from purchasing new vehicles and keeps less fuel-efficient vehicles on the road for longer. The analysis provided in the proposal's accompanying Draft Regulatory Impact Analysis (EPA 2025) misinterprets the findings of research literature—in particular, Leard, Linn, and Zhou (2023)— causing the EPA analysis to overstate the net benefits of revoking the GHG standards.

1. Estimates of vehicle ownership behaviors misinterpret the literature.

We first discuss consumer behaviors related to vehicle choice. EPA (2025) claims that consumers are close to rational actors, in that consumers would pay for full value of fuel cost savings. Supporting this assertion, Table 1 in EPA (2025) shows studies that report "close" to full valuation. The table includes our (that is, Leard, Linn, and Zhou (2023)) preferred estimate of a 54 percent valuation. This number means that, if a consumer can choose between two vehicles that are identical to one another, except that one is expected to save the consumer $100 over the vehicle's lifetime, the average consumer would be willing to pay an additional $54 for that vehicle. The same table also reports our estimate of a 73 percent valuation ratio that we report in the paper's online appendix. The point of reporting 73 percent in the appendix is to show that using outdated data leads to a higher valuation ratio. Our preferred estimate of 54 percent used the most recent data that was available at the time, and it is not inaccurate for EPA (2025) to claim that we report a range between 54 and 73 percent.

EPA (2025) also claims that we report valuation ratios of 54–77 percent depending on the discount rate. We assume that the 77 percent value is taken from an online appendix table that reports results using a 7 percent discount rate. However, the calculation aims to illustrate the sensitivity of the valuation ratio to the choice of discount rate. As we argue in the paper, a discount rate of about 3 percent is appropriate in this context because, during the period we analyzed (2010–2014), most consumers were able to borrow at interest rates of 3 percent or lower. Thus, our research does not imply that consumers "close" to fully value fuel cost savings—valuing about half of the savings is certainly not "close" to full. It is inappropriate to provide a range of 54–73 or 54–77 percent, given that the upper values of that range are computed using outdated data and an excessively high discount rate.

EPA (2025) explains that manufacturers and industry report payback periods of 2.5 years. For a consumer choosing between a fuel efficient and more expensive vehicle and an inefficient less expensive vehicle, this number means that a consumer would buy the fuel-efficient vehicle if the first 2.5 years of fuel cost savings justify the higher purchase price. A payback period less than the vehicle's expected lifetime indicates that consumers are not fully valuing fuel cost savings. The payback period is related to the valuation ratio in that a higher valuation ratio indicates a longer payback period. For example, our estimated valuation ratio of 54 percent implies a 7-year payback period; a payback period of 2.5 years is consistent with a 20 percent valuation ratio.

To reconcile the supposed full valuation and 2.5-year payback period, EPA (2025) asserts that there are "missing costs" associated with fuel-saving technologies. EPA (2025) fails to define the term; but, generally, economics literature (which often uses the term "hidden costs") defines them as attributes of fuel-saving technologies that consumers do not like. As a hypothetical example, if consumers do not like the "feel" of how a hybrid vehicle drives, that would constitute a missing or hidden cost. The argument in EPA (2025) is that, if one were to give a consumer fuel cost savings without any missing costs, the consumer would fully value the fuel cost savings when choosing a vehicle. However, these technologies have additional features besides saving fuel, which consumers do not like. Instead of valuing the efficient vehicle based on the full present discounted value (PDV) of the fuel cost savings, the consumer is willing to pay only for the first 2.5 years. Therefore, the missing costs equal the difference between the PDV and the first 2.5 years of fuel cost savings.

EPA (2025) notes that it could attempt to model how the standards affect the attributes that tend to accompany fuel-saving technologies, such as forgone performance or the apparent disutility of owning a battery electric vehicle (BEV). If a manufacturer offers two vehicles that are identical to one another, except that one is gasoline and the other is a BEV, and the two vehicles have the same lifetime ownership cost (including purchase price, fuel costs, maintenance, etc.), most consumers choose the gasoline vehicle over the BEV. In this case, the missing cost is the monetary value of the disutility that the consumer gets with the BEV instead of the gasoline vehicle. The missing cost makes it harder for the manufacturer to comply with GHG standards because it has to offer a discount on the BEV (that is, compared to the price it could charge if missing costs were zero).

Given this background, we offer two arguments as to why the 2.5-year payback period is inappropriate for approximating the missing costs of BEVs. EPA (2025) argues that including the first 2.5 years of fuel cost savings accounts for the "missing costs". However, the analysis also argues that the 2024 standards amount to an electric vehicle mandate. In that case, EPA (2025) should use an estimate of missing costs that corresponds specifically to BEVs. Although EPA (2025) does not cite specific sources for this 2.5-year payback period, the sources appear to predate the rise of BEVs in the US market. For that reason, using the 2.5-year payback period to approximate missing costs of BEVs is unsupported by evidence, since that number has been reported to EPA in a completely different context.

Moreover, the EPA (2025) interpretation of the 2.5-year payback period is inconsistent with our analysis. A distinguishing feature of our paper (Leard, Linn, and Zhou 2023) is that we estimate consumer valuation of fuel cost savings specifically when manufacturers add fuel-saving technologies to the vehicles they offer. During the early 2010s, these technologies included things such as cylinder deactivation. If there were indeed missing costs, they would be included in our valuation estimate. Therefore, our results are inconsistent with missing costs causing consumers to insist on a 2.5-year payback period.

As noted above, our preferred estimate of a 54 percent valuation ratio is consistent with a 7-year payback period rather than a 2.5-year payback period. In fact, our results are consistent with a minimum of a 7-year payback period. EPA (2025) explains the 2.5-year payback period as being consistent with supposed missing costs, but there's a second explanation: consumer behavior. The recent economics literature has identified numerous reasons why consumers may undervalue fuel cost savings, such as rational inattention (Sallee 2014). Vehicles differ from one another across many dimensions, such as reliability, safety, comfort, and expected fuel costs. If a consumer is choosing among several vehicles across which fuel costs vary relatively little, and it is costly for the consumer to process all the relevant information about the vehicles, it may be rational for the consumer place as much emphasis on the fuel cost savings for their vehicle of choice. Another behavioral explanation is simply that some consumers may make mistakes, passing up opportunities to save money by choosing vehicles with higher fuel economy.

Most of the papers EPA (2025) cites in Table 1 identify consumer valuation from variation in gasoline prices, and consumers may respond differently to gasoline prices than to changes in fuel economy for reasons beyond missing costs. Some consumers may ignore small fuel economy changes to focus on other differences in attributes. For example, suppose a consumer is deciding between two small SUVs produced by different manufacturers, which have different safety ratings, cargo space, and so on. Suppose one manufacturer were to adopt fuel-saving technology and increase the miles per gallon, or mpg, of one of those options, and that this technology adoption does not impose any missing costs. Given cognitive costs of considering so many attributes simultaneously, some consumers may ignore that fuel economy change to focus on the other vehicle attributes. That would cause us to estimate a valuation ratio of less than one, which is explained by the consumer's inattention rather than any missing costs.

If any of these behavioral explanations account for the 54 percent valuation ratio we estimate, the 7-year payback period is a lower bound to the payback period. In fact, our results are consistent with using the full PDV of fuel cost savings when EPA (2025) adds up the benefits and costs of the proposed rule. Since we have not found direct evidence of missing costs in our analysis, we have used the full PDV in subsequent peer-reviewed research (Leard, Linn, and Springel 2023).

Conceptually, the EPA (2025) methodology creates two sources of errors when computing the net benefits of changing the standards. The EPA assumes that the standards do not affect performance, or other attributes that consumers care about, other than fuel economy or powertrain type (for example, converting a gasoline vehicle to a full hybrid). The first source of error comes from assuming that manufacturers cannot reduce emissions by trading off performance for fuel economy. EPA (2025) overstates the costs of tightening standards because the agency only models a subset of available compliance options (Klier and Linn 2012).

The proposal to revoke the standards introduces a second source of error by approximating the missing costs of reducing emissions. Examples of missing costs include disutility from charging inconvenience or changes in maintenance costs from owning a battery electric vehicle instead of a gasoline vehicle. EPA (2025) argues that these missing costs equal the difference between the PDV of the fuel cost savings and the first 2.5 years of fuel cost savings. If the actual missing costs are smaller than this amount, EPA (2025) underestimates the benefits of tightening the standard, and vice versa if the actual missing costs are larger.

We use the same simulation model as Leard, Linn, and Springel (2023) to show that using a short payback period to approximate missing costs overstates manufacturer compliance costs and understates the benefits of tightening the standards. Both sources of error cause EPA (2025) to overstate the benefits of revoking the standards. Our model estimates the benefits and costs of tightening the standards between 2012 and 2025. Input data includes fuel prices, battery costs, total vehicle demand, and California Zero Emission Vehicle requirements from 2024 (the most recent year for which all data are available). We predict vehicle fuel economy, performance, prices, and sales, assuming consumers choose vehicles to maximize subjective utility and that manufacturers choose vehicle prices and technology to maximize profits.

Table 1. Implications of Using a Short Payback Period to Approximate Missing Costs

	Welfare changes caused by 2022 standards (billion 2018 US$)	
	(1) Include horsepower changes and full value of savings	(2) Approximate costs of horsepower changes using shorter payback period
Vehicle production costs	47	121
Manufacturer profits	–7	–10
Consumer welfare	32	–128
Climate benefits	72	79
Total welfare	**96**	**–59**
Total welfare, excluding climate benefits	**24**	**–137**

Notes: The table reports simulation outcomes using the same computational model as Leard et al. (2022). All numbers are in billions of US 2018 dollars. Both columns report welfare changes caused by simulating the model-year 2022 standards compared to the 2012 standards. Column 1 allows manufacturers to comply by adopting fuel-saving technology, trading off horsepower for fuel economy, and reducing relative prices of vehicles with emissions rates below their targets. Column 2 is the same, except that manufacturers cannot trade off horsepower for fuel economy. Manufacturer profits include revenues net of production costs, subsidies, and net credit expenditures. Consumer welfare in column 1 uses the full present discounted value of fuel cost savings. Consumer welfare in column 2 uses consumer preference parameters to value the fuel cost savings. In both columns, consumer welfare is reported net of subsidies. Climate benefits use the social cost of carbon of $190 per metric ton. Welfare excluding climate benefits equals the difference between total welfare and climate benefits.

Column 1 of Table 1 reports changes in manufacturer profits, consumer welfare, and climate damages caused by the actual model-year 2025 GHG standards, compared to a counterfactual of imposing the model-year 2012 standards. Manufacturers comply with tighter standards by adding fuel-saving technologies, foregoing horsepower to increase fuel economy, and reducing relative prices of vehicles with emissions rates below their class and footprint-based targets. The table shows that technology adoption raises production costs by about $47 billion.

However, manufacturers are able to pass most of the compliance costs to consumers, and their profits fall by about $7 billion (about 6 percent). Consumers gain about $32 billion in welfare because the present value of lifetime fuel cost savings outweigh the higher vehicle prices and lower horsepower. The second column approximates EPA's (2025) approach to incorporating missing costs. We simulate the same standards as in column 1, except that we hold horsepower fixed. Based on consumer vehicle choices from 2010–2018, we estimate that consumers are willing to pay for the first four years of fuel cost savings. Because all other model parameters are estimated using the same data, we use the 4-year payback period rather than the EPA's assumed 2.5-year payback for this column.

Comparing the two columns reveals three conclusions. First, holding horsepower fixed raises vehicle production costs, since manufacturers do not have the opportunity to trade off horsepower for fuel economy. Second, the EPA approximation overstates consumer welfare losses by about $160 billion, meaning that using the first four years of fuel cost savings rather than the PDV vastly overstates the missing costs of forgone horsepower. Third, the approximation leads one to incorrectly infer that the tighter standards reduced social welfare and that repealing the standards would have positive net benefits. Although the short comment period prevents us from performing a similar exercise using the 2024 standards that apply through model-year 2032, the results in Table 1 indicate that the RIA (EPA 2025) overstates the benefits of revoking the standards.

2. The proposal's assumptions about vehicle manufacturer behaviors are unjustified.

EPA (2025) should also justify its assumptions about manufacturer behavior and market outcomes if it revokes the standards. EPA (2025) requests comment specifically on the expectations for vehicle fuel economy and greenhouse gas emissions in the coming years, absent of the 2009 Endangerment Finding (p. 46), which we provide here.

It appears that the benefits and costs in Table 2 are computed by comparing scenarios from the EPA's 2024 analysis of the GHG standards. If that is correct, then they are comparing two scenarios: a) maintain model-year 2026 GHG standards for all subsequent years and b) tighten standards through 2032 and then maintain them. The first scenario (a) represents a continuation of the status quo prior to those standards—that is, if the EPA had maintained the standards it had adopted in 2021, which tightened through 2026 and then remained unchanged afterwards. The second scenario (b) corresponds to the standards the Biden administration adopted.

If the EPA was to be proposing to revert to the standards adopted in 2021, then we agree that the EPA should be comparing the same two scenarios that were compared in the 2024 final RIA. However, EPA (2025) is not proposing to revert to the 2021 standards. Instead, the proposal is preparing to eliminate the standards altogether. The comparison in EPA (2025) would only be appropriate if all manufacturers respond to eliminating standards by behaving as if they continue to face the standards that were adopted in 2021. This seems unlikely because, as the EPA noted, the standards incentivize manufacturers to reduce the average emissions rates of their vehicles. Because tax credits are traded, all manufacturers receive this incentive—although, as we discuss below in our comments on the appendix to EPA (2025), this incentive may not equal marginal abatement costs if firms have market power in the credit market. The credit price incentivizes manufacturers to reduce emissions any way they can, such as adopting fuel-saving technologies, offering new BEVs or hybrids, or other innovations. Revoking the standards amounts to setting the credit price to zero, eliminating these incentives for manufacturers.

Responses may vary across manufacturers. For some manufacturers, they may maintain relatively high fuel economy or electric vehicle offerings in hopes of attracting customers who are concerned about fuel costs or the environment. Manufacturers may also develop vehicles for other markets with CO_2 standards, such as Europe, and introduce similar vehicles in the United States. Nonetheless, even for those manufacturers, eliminating the incentive may cause them to raise prices of their BEVs or hybrids (Jacobsen 2013). Other manufacturers may withdraw from the market, low-selling BEVs or hybrids, or perhaps remove fuel-saving technologies from their vehicles. In short, there is no reason to believe that manufacturers will make the same choices if the EPA revokes the standards that they would have made instead, where the EPA maintains standards at model-year 2026 levels.

Assuming manufacturers have responded rationally to the standards and maximize profits, the benefit-cost analysis in the RIA could overstate the net benefits of revoking the standards. To illustrate this possibility, we note that the RIA for the 2021 standards estimated that the fuel cost savings would exceed the technology costs. The implication is that if EPA (2025) correctly predicted compliance behavior of achieving the 2021 standards, and manufacturers undo their compliance behavior, the benefits of replacing the 2021 standards with the Safer Affordable Fuel-Efficient (SAFE) rule would be less than the costs. Obviously, this discussion does not account for economic conditions that may have changed, such as fuel prices, or any sunk costs of technology adoption. The point is, simply, that if the fuel cost savings of the original standards exceeded the technology costs, the benefits of revoking the standards would exceed the costs. By failing to account for this response, the EPA may overstate the benefits of revoking the standards in EPA (2025).

The proposal does not fully account for all associated economic costs and benefits from changes in emission standards in its economic analysis. The approach to benefit-cost analysis in this proposal-specifically, ignoring the benefits leading to the $2.1 net benefits in the EPA's 2024 regulatory impact assessment—does not reflect the current state of the scientific literature nor is it consistent with the EPA's previously held analysis for costs and benefits for the last decade.

Again, we turn to the draft regulatory impact analysis associated with the proposal (EPA 2025), particularly its Appendix B Section C.2, which estimates the costs of the 2024 standards by linearly extrapolating estimated costs of prior standards. After reviewing the EPA (2025) methodology, we explain that incorporating up-to-date data, correctly interpreting the data, and accounting for recent changes in hybrid and electric vehicle markets reduces estimated costs dramatically. More specifically, our main conclusions are that:

1. The EPA's approach departs from historical methods for estimating vehicle technology costs; and the agency has failed to explain its departure from precedents or establish the credibility of this approach.

2. The EPA's estimates are sensitive to key assumptions, such as the relationship between compliance costs and regulatory stringency, which the EPA does not justify. The estimates rely on obsolete data and the EPA's assumptions are inconsistent with market data. For example, the EPA's cost model predicts higher tax credit prices than have occurred.
3. Even hypothetically accepting the EPA's methodology, using the most up-to-date data per the data of the proposal and making assumptions consistent with the data reduces estimated costs by 80–90 percent. For example, the EPA estimates costs of $18,000 per vehicle, which RFF estimates at $1,800–3,600 per vehicle. RFF estimates are in line with EPA cost estimates from prior rules, preceding their 2025 analysis.

Given the sensitivity to assumptions, failure to use current data, and improper interpretation of the data, the EPA (2025) methodology does not yield credible cost estimates.

3. The proposal employs unjustified methods and outdated data.

EPA (2025) prominently features cost estimates obtained from an extrapolation methodology. Section 6, titled "Summary of results", reports that, using the extrapolation methodology, eliminating the GHG standards would yield annual cost savings of $160–440 billion (depending on extrapolation methodology and discount rate). These savings are an order of magnitude larger than the savings the EPA reported previously, using other methods.

The standards are set in units of grams of carbon dioxide (CO_2) per mile, which is the reciprocal of the number of miles a vehicle could be driven per ton of CO_2 emissions. Therefore, setting more stringent standards amounts to increasing the number of miles the average vehicle could be driven per ton of CO_2 emissions (MPT). For a given carbon content of fuel, MPT is directly proportional to a vehicle's mpg equivalent.

EPA (2025) asserts that the compliance costs increase linearly with the stringency of the standards, as measured in MPT or mpg. We follow the EPA convention of referring to the standards based on the year in which the rule was finalized. The agency takes two approaches to estimate costs of 2024 standards—that is, the standards EPA adopted in 2024 that cover 2027–2032. Both approaches assume linear relationships between costs and stringency of the standards.

The first uses the SAFE rule as a baseline and the agency's modeling of the 2021 rule that estimated that, compared to the SAFE rule, the 2021 rule would cost an additional $1,154 per vehicle (2022 US$). Compared to the SAFE rule baseline, the EPA estimates that the 2024 rule increases MPT 5.5 times more than the 2021 rule.[1] From the linearity assumption, it follows that the 2024 rule costs $6,338 (or, 5.5 * $1,154) per vehicle, relative to the SAFE rule baseline.

The second approach assumes that marginal compliance costs increase linearly with the mpg-equivalent of the standards. This approach differs from the first because, rather than using EPA (2025) estimates of compliance costs, the agency estimates costs from manufacturer behavior—what the agency refers to as a "revealed preferences" approach.

EPA (2025) derives two estimates of marginal costs for different levels of the standards, fits a line through those data points, and extrapolates to estimate costs of more stringent standards (see Figure RIA-3). The first data point is estimated from Anderson and Sallee (2011), who use the flex-fuel vehicle loophole that was available in the CAFE program, and estimate costs of $18 per mpg when the standards were about 24.8 mpg

[1] Specifically, Table RIA-3 reports that the 2021 rule increased MPT by 1,236 compared to the SAFE rule. The 2024 rule increased MPT by 6,790 compared to the SAFE rule.

(2018 US$). The second data point is estimated from compliance credit transaction data, following the calculations in Center for Environmental Accountability (CEA2020). The CEA (2020) analysis assumes that manufacturers minimize compliance costs and that firms can freely trade tax credits. Under these assumptions, the credit price equals the marginal compliance cost, which is defined as the change in industry-wide average per-vehicle compliance costs caused by infinitesimally increasing the stringency of the standards.

Because the EPA does not report prices of compliance credits, CEA (2020) follows an approach from Leard and McConnell (2017) and infers this price by dividing the revenues that Tesla has earned from credit sales by the number of credits the company has earned. Based on data from 2012–2016, CEA (2020) finds an average credit price of $86 per ton of CO_2 (in 2018 US$). This estimate is the basis for the EPA's revealed preference calculation of compliance costs (see the Market data columns in Table 4 of EPA (2025)).

To replicate and extend the CEA (2020) analysis, we first collect Tesla regulatory credit revenues from form 10-K reports for the years 2012–2016. For 2014–2016, the reports do not distinguish regulatory credit revenues earned from the sale of GHG credits and California Zero Emission Vehicle (ZEV) credits. We follow the CEA (2020) and use Forbes (2017), which reports ZEV-specific revenues for this period. We obtain the number of credits that Tesla sold from the EPA's Manufacturer Performance Report for the 2016 model year (see Table 4-1 in that document). Following the CEA, we standardize all revenues as if they were earned in 2016 using a 7 percent discount rate. Dividing the total revenue by credit sales over this period yields an average credit price of $86 per ton of CO_2 (in 2018 US$), which is the same as CEA (2020). This credit price corresponds to a price of $116 per mpg (2018 US$), which is consistent with CEA (2020).[2]

The two cost estimates at different points in time, $18 per mpg and $116 per mpg (2018 US$), correspond to the marginal cost of tightening the standards from a starting point of 24.8 mpg and an ending point of 35.8 mpg. Assuming marginal costs increase linearly with the mpg requirement, these two estimates imply that the marginal cost increases at a rate of $8.91 per mpg per vehicle (2018 US$). Combining that rate of increase and the formula for computing the area of a trapezoid (see Figure RIA-3 and Figure 1 below) makes it possible to compute the costs of any other change in the standards. CEA (2020) estimates that increasing the standards from 45.6 mpg to 54.5 mpg, which are approximately the requirements of the SAFE and 2012 standards, was $2,538 per vehicle. Extrapolating further, to compare the costs of the 2024 standards with the SAFE rule, the EPA estimates that the 2024 standards would cost about $18,000 per vehicle. After converting these per-vehicle cost estimates to industry-wide estimates, the EPA reports that the 2024 rule would cost "at least $270 billion annually relative to the SAFE rule…the costs to vehicle consumers of the 2024 LMDV rule must exceed $100 billion annually and likely near $300 billion" (EPA 2025, p. 52).

4. The proposal overestimates compliance costs.

We present three reasons why compliance costs are lower than EPA (2025) estimates: a) more recent data indicate lower credit prices; b) market power causes credit prices to be higher than marginal costs; and c) even if the US$ per mpg relationship were linear, changes in market demand and technology reduce the sensitivity of costs to changes in mpg.

Before presenting those arguments, we note that we are not aware of any evidence supporting the assumption that costs increase linearly with MPT or mpg. The EPA (2025) and CEA (2020) linearity assumption implies that increasing miles per gallon twice as much (say from 45–65 mpg instead of 45–55

[2] Converting from units of dollars per metric ton to units of dollars per mpg requires assumptions on the lifetime miles a vehicle is traveled and a choice of base mpg and mpg increment. Throughout our comments we use the same miles traveled assumption as CEA (2020). We use the base mpg and increment to match the CEA figure of $116 per mpg, and for subsequent conversions in these comments we adjust the base mpg to match the context. We note that the conversion is sensitive to the choice of base mpg.

mpg) doubles the marginal cost of compliance. EPA (2025) does not justify this assumption, which raises the question of the sensitivity of the cost estimates to this functional form assumption. For example, costs may scale less than linearly with mpg, perhaps due to anticipated decreases in battery costs (which the EPA analysis ignores), or because costs may really scale in proportion to the change in the emissions rate (grams of CO_2 per mile, which is inversely related to MPT). If costs are proportional to the emissions rate, cutting the emissions rate by 20 percent would be twice as costly as cutting it by 10 percent. This may sound similar to the EPA's (2025) functional form, but it would imply much lower costs. For example, using the numbers in Table RIA-3, the costs of the 2024 standards rather than 2012 standards would be 3.5 times higher rather than 6.9 times higher. In other words, choosing a different functional form and otherwise using the same numbers as the EPA reduces compliance costs by 50 percent. Thus, the choice of functional form is important and lacks support. Our argument is not that the correct functional form is for costs to scale with the emissions rate, but rather that the choice of functional form has a large effect on the cost estimates, and yet EPA (2025) does not provide evidence supporting its choice.

Notwithstanding the unsupported linearity assumption, we proceed for the sake of argument that there is a linear relationship between marginal costs and the mpg requirement of the standard, rather than emissions or fuel consumption rate. We show that the EPA (2025) analysis vastly overestimates compliance costs.

4.1. New data indicates that credit prices have fallen substantially since 2016.

EPA (2025) claims that "tighter standards [are] associated with substantially greater regulatory credit prices" (p. 51). While this may be true in a simplified view of the standards, in which technology and consumer preferences are unchanging, after considering the effects of technological progress and changes in consumer preferences, it is no longer obvious that tightening standards over time causes credit prices to increase "substantially." We present more recent data than EPA (2025), which indicates that tighter standards have led to smaller credit price increases than the EPA model predicts.

EPA (2025) relies on an extrapolation that projects compliance costs under a 45 mpg-equivalent GHG standard to equal $203 per mpg. The 2021 standards required manufacturers to achieve about 45 mpg-equivalent by 2026.[3] Consequently, to the extent that the 2012–2016 credit prices are relevant to standards of 35.8 mpg (because the transactions occurred before the SAFE rule was adopted), the 2023 credit prices, which reflect trades made before the 2024 standards were adopted, are relevant to the 2021 standards. The 2021 standards average to about 40 mpg for model years 2023–2026.[4][4]

Table 2 shows the results of our credit price calculations. For comparison with our numbers, the first two rows show the calculations from CEA (2020) adjusted to 2018 US dollars. The third row in Table 2 reports the average credit price for 2017–2018 using the same data and methodology that we used to compute the 2012–

[3] Because cars face lower emissions rate requirements than light trucks do, an increase in the market share of light trucks reduces the mpg requirement of the standards. Market shares of light trucks have exceeded the EPA's forecasts in 2012, which the RIA does not appear to consider. For instance, when we account for the increasing market share of light trucks, we calculate a 32.3 mpg standard for 2012–2021 period, which is lower than the CEA's (2020) 35.8 mpg standard used by the EPA (2025).

[4] Because the credits can be banked, in theory credit prices should reflect expected compliance costs far into the future. Consequently, the 2023 prices may include expectations about standards after the 2026 model year. A similar argument pertains to using the 2012–2016 credit prices to approximate compliance costs for 2012–2021, as CEA (2020) does (although individual credits can only be banked for 5 years, because firms can strategically retire accumulated credits, prices can reflect expectations more distant than 5 years in the future). That credit prices include expectations about future standards is an additional reason why one cannot simply equate credit prices with marginal compliance costs of any particular level of the standards.

2016 prices. We calculate that the 2017–2018 average credit price was substantially lower, by about 63 percent when comparing the price expressed dollar per mpg units, than the price for the 2012–2016 period.

Table 2. Calculation of Compliance Credit Prices (2018 US$)

Period	Average Credit Price or Cost (2018 dollars)	Regulatory Standard	Comments
2011	$18 per mpg	24.8 mpg	Calculated by Anderson & Salle (2011)
2012–2016	$86 per ton or $116 per mpg	35.8 mpg	CEA-calculated with Tesla SEC filings, Forbes (2017) and 2016 EPA Manufacturer Performance Report
2017–2018	$28 per ton or $43 per mpg	32.3 mpg*	RFF-calculated with Tesla SEC filings and 2016 and 2019 EPA Manufacturer Performance Report
2023 (upper bound)	$44 per ton or $54 per mpg	39.8 mpg	Taken as an upper bound, as calculation includes ZEV credits due to data limitations. Exclusion of ZEV revenue would only decrease price. RFF-calculated with Tesla SEC filings, 2023 and 2024 EPA Manufacturer Performance Report
2023 (ZEV-adjusted)	$33 per ton or $41 per mpg	39.8 mpg	Assumes ZEV contribution to regulatory credit revenue is 25 percent—the level in 2018, when data were last available. RFF-calculated with Tesla SEC filings, 2023 and 2024 EPA Manufacturer Performance Report

**We derive the regulatory standard following the CEA's (2020) 2012–2021 time window used for 2012–2016 price, but account for the growing share of light-duty trucks in the market using sales data. Light-duty trucks are subject to a considerably lower regulatory standard. The CEA's method of calculating the prevailing regulatory standard for the 2012–2021 period is unclear in the SAFE report.*

Computing credit prices after 2019 is more challenging than in earlier years because in 2019, Tesla stopped reporting California ZEV credit sales revenues separately from GHG credit revenues in SEC filings. We present two credit price calculations. The first does not attempt to exclude ZEV revenues, which therefore represents an upper bound on the GHG credit price because subtracting ZEV credit revenues would reduce the calculated price. The second price assumes a 25 percent ZEV revenue share, which was the value in 2018, which is the last year data were available.

Using similar data sources that we used to replicate the CEA (2020) estimates of the 2012–2016 prices, we estimate that 2023 credit prices corresponding to standards of 45 mpg were about $68 per mpg per vehicle—that is, 67 percent lower than EPA's predicted credit price of $203. The 2023 prices are similar to the 2017–2018 price that the table reports, which indicates that 2023 credit prices increased only slightly during a period in which the standards tightened. The slight increase is inconsistent with the EPA (2025) assumption that the credit prices should increase rapidly as the standards tighten.[5] Table 2 reports different average

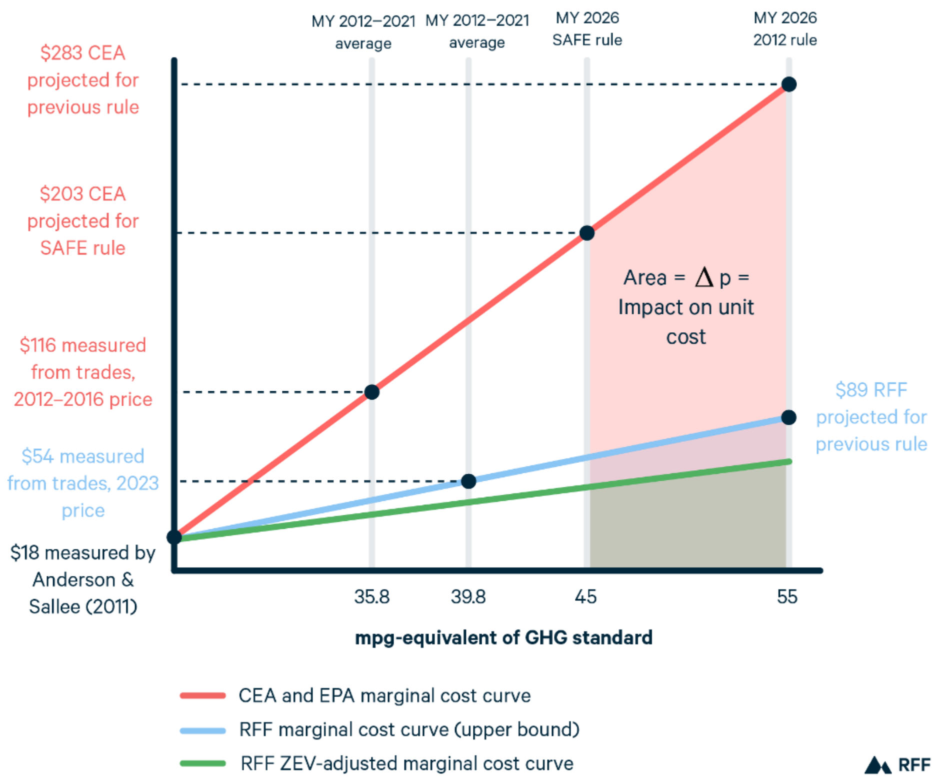
[5] As noted above, expectations of future standards may affect credit prices. The 2017–2018 credit prices may reflect weaker anticipated standards than the 2023 credit price, to the extent that manufacturers anticipated the adoption of the SAFE rule. Note that the reduction in credit prices between 2012–2016 and 2017–2018 may partially reflect changes in expectations.

credit prices by period and regulatory standard, demonstrating that the CEA/EPA prediction of marginal costs for the 2021 standards is considerably higher than the recent credit prices have been.

Figure 1 below reproduces the figure CEA (2020) uses to illustrate its method for computing compliance costs from the estimated credit price (see Figure 4). We note that the Anderson and Sallee (2011) data point was estimated from compliance behavior before the EPA began regulating GHG emissions, and that the flex-fuel vehicle credits are no longer available. It is unclear why these cost estimates are relevant to the proposal, given that they derive from a prior regulatory regime using a defunct compliance option. Notwithstanding this point, for the sake of comparability with the EPA cost estimates, we continue using the same data point.

CEA (2020) computes the per-vehicle cost of the 2012 standards relative to the SAFE rule by integrating under the marginal cost curve. The red, blue, and green regions combined represent the compliance costs, which CEA computes as $2,538 per vehicle (2022 US$) by calculating the area shaded in red under the marginal cost curve.

Figure 1. Adapted GHG-Credit Market Equilibrium for Various Standards



Sources: CEA (2020); Tesla SEC 10-K filings for years 2012–2023; Forbes (2017); EPA Automotive Trends Reports; Author calculations. See Figure 4 in the CEA's SAFE report for comparison.

This figure shows that the EPA's method of determining per-vehicle cost is highly sensitive to the estimated marginal cost for two measured values for compliance credits. The red, blue, and green lines share the Anderson and Sallee (2011) estimated cost as the first datapoint. The blue and green lines use the 2023 credit prices that we compute (see Table 1) to estimate marginal costs, rather than the 2012–2016 prices from CEA (2020). CEA (2020) predicts a credit price of $283 at 54.5 mpg, whereas we predict credit prices of $64–89—less than one-third of the CEA (2020) prediction.

Table 3 reports the shaded region under the marginal cost curves for the estimation and the two credit prices that we computed using the 2023 data. An important difference between the CEA/EPA cost estimates and ours is that they extrapolate to 45 mpg the credit prices that correspond to 35.8 mpg, whereas we use credit prices that correspond to 39.8 mpg, reflecting the regulatory environment at the time.

Table 3. Implications of Updated Credit Price Data for Unit Costs

Estimation	Credit Price Utilized (2018 US$)	Per-vehicle compliance costs (2022 US$)
CEA/EPA estimated credit price, 2012–2016 data	$116 per mpg at 35.8 mpg	$2,538
Marginal costs estimated from 2023 data, upper bound	$54 per mpg at 39.8 mpg	$916
Marginal costs estimated from 2023 data, adjusting for ZEV credit revenue	$41 per mpg at 39.8 mpg	$661

The table shows that the estimated compliance costs fall dramatically using more recent data than the data CEA uses. Using more recent data reduces estimated compliance costs by 64–74 percent, depending on whether we adjust for ZEV credit revenue.

The assumed linearity between mpg and marginal costs implies that the EPA (2025) compliance cost estimates for the 2024 rule should be scaled down proportionately. For example, EPA estimates per-vehicle costs of $18,000 for the 2024 rule relative to the SAFE rule. If the EPA used more recent credit price data instead, their per-vehicle estimates would fall proportionally—that is, by 64–74 percent.

4.2. Credit prices are likely to exceed marginal compliance costs.

EPA (2025) uses credit prices to infer marginal compliance costs. While we agree that credit prices can provide useful information about compliance costs, credit prices are only informative if they are used in a manner that is consistent with economic theory and market conditions. This section explains why EPA's (2025) interpretation of credit prices is inconsistent with economic theory market data. Consequently, the EPA overestimates marginal costs substantially.

EPA (2025) asserts that the credit price equals the industry-wide marginal cost of compliance across the industry. This claim is consistent with standard environmental economics textbook theory, which lies under the assumption that all firms participating in the credit market take the credit price as exogenous to their decisions. We provide data in this section that refutes this assumption. We estimate that in 2022 the market-wide marginal cost may have been 55 percent lower than the credit price.

We summarize how credit prices are determined in the market. The GHG standards create an emissions rate target, measured in grams of CO_2 per mile, for each vehicle that depends on its regulatory class (car or light truck) and footprint. If the vehicle's tested emissions rate is below its target, the producer earns CO_2 credits in proportion to the number of units of production and the difference between the target and tested emissions. If the tested emissions rate is above the target, the firm earns a credit deficit. If firms could not trade or use banked credits, the firm's production-weighted average target would have to equal its production-weighted average emissions rate.

The program offers manufacturers compliance flexibilities. If a manufacturer earns a surplus, it can sell excess credits to other firms or bank them for future use. If it has a deficit across its vehicles, it can buy from other firms or use credits it has banked in prior years. Thus, if a manufacturer expects to have a deficit, it has three options. First, it can reduce emissions rates of its vehicles, perhaps by converting a pure gasoline vehicle into a strong hybrid vehicle. Second, it can introduce new vehicles to the market that have emissions rates below their targets. Third, it can buy credits from other firms.

The economic theory on which CEA (2020) relies indicates that firms reduce their emissions as long as the marginal cost of doing so, which we refer to as the marginal abatement cost, is below the credit price. Note that, in this context, the marginal abatement cost is the change in the firm's profits caused by reducing emissions, which includes direct costs of adding technology as well as changes in revenue and production costs if the firm adjusts vehicle prices and sales.

The credit system is more efficient than requiring each firm to meet the standards solely on its own because abatement costs can vary across firms. Some firms may have technological advantages or better marketing strategy, for example, which causes them to have lower marginal abatement costs than other firms. The low-cost firms will abate more than other firms and be able to sell excess credits. These credit trades reduce overall industry-wide compliance costs, compared to restricting or not allowing trades at all.

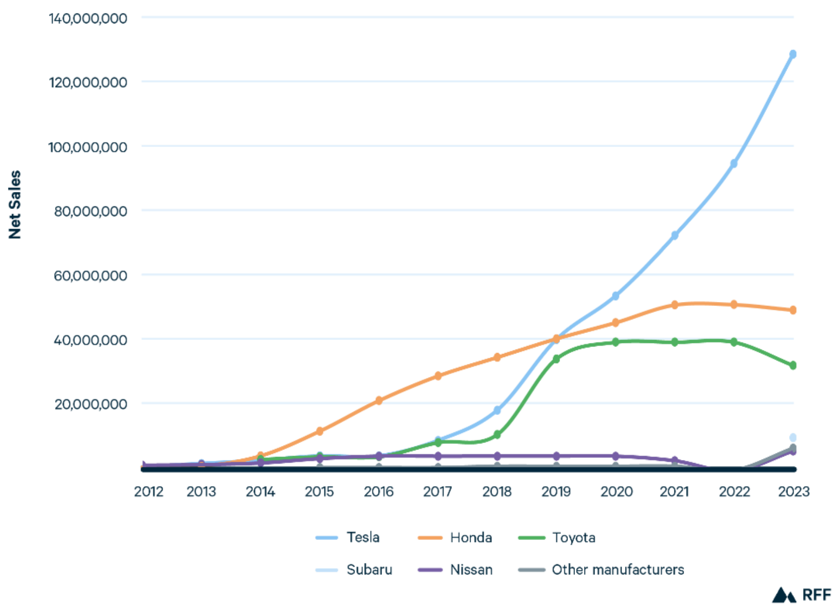
Because compliance credits can be banked for future use, the credit price at any time reflects compliance costs at that time as well as expectations about future compliance costs. Future costs depend on many factors—such as gasoline prices, consumer demand for electric vehicles, and regulatory stringency. Notwithstanding this complication, for the sake of argument we adopt the EPA (2025) methodology of assuming away the effects of expectations on the credit price data used to estimate compliance costs.

Economic theory also predicts that, if firms have market power in selling credits, the credit price exceeds the marginal abatement cost (keep in mind that market power refers to the ability of a seller to raise prices by restricting supply). The fewer firms there are that can realistically supply credits, the more likely firms have market power. In fact, data on compliance behavior and credit transactions indicates that credit sellers are likely to have market power. We next present evidence that certain manufacturers were likely to exercise market power in the GHG credit market, thereby setting credit prices above marginal abatement costs.

Figure 2 shows the cumulative number of net credits sold by manufacturers that are net sellers as of 2023. We created this figure from the 2012–2016 Greenhouse Gas Emissions Standards for Light-Duty Vehicles Manufacturer Performance Reports and 2018–2024 EPA Automotive Trends Reports, which include data on credit transactions. These reports include tables with annual snapshots of the cumulative number of credits bought or sold for each manufacturer.

The EPA's 2012–2016 reports provide trading activity for the corresponding model-year credits, and the EPA's 2018–2024 reports provide cumulative trading activity through the prior model year. For example, the 2024 report includes cumulative net purchases (with credit sales represented as negative numbers) through the 2023 model year. In Figure 2, net credits sold are defined as credits sold minus credits purchased. The figure includes manufacturers reporting positive cumulative net credits sold as of 2023.

Figure 2. Cumulative net credits sold by manufacturers with net sales as of 2023



Source: The data in the figure are collected from 2012–2016 Greenhouse Gas Emissions Standards for Light-Duty Vehicles Manufacturer Performance Reports and 2018–2024 EPA Automotive Trends Reports.

Note: Manufacturers with net sales as of 2023 are defined as those with a negative cumulative balance for credits purchased or sold. Manufacturers in the Other manufacturers category include Coda, Hyundai, Karma, Lucid, Mazda, Rivian, Suzuki, and Volvo. For 2012–2016, we show data from the Total column of Table 4-1 in each report. For 2017 and 2018, we show data from the Credits purchased or sold column of Table 5.17 in the 2018 and 2019 reports, respectively. For 2019 and 2020, we show data from the Credits purchased or sold column of Table 5.18 in the 2020 and 2021 reports, respectively. For 2021–2023, we show data from the credits purchased or sold column of Table 5.19 in the 2022–2024 reports, respectively.

In Figure 2, if a line showing a firm's net credits increases from one year to the next, the firm was a net seller of credits in that year. Honda was the largest net seller during the late 2010s, and Toyota was also a relatively large seller at the very end of the decade. However, in recent years, these companies appear to have been buyers of credits, as their cumulative number of credits sold has slightly declined. Because of this change in credit transactions, we use the term "net credits sold" to allow for the possibility of a historical seller becoming a buyer.

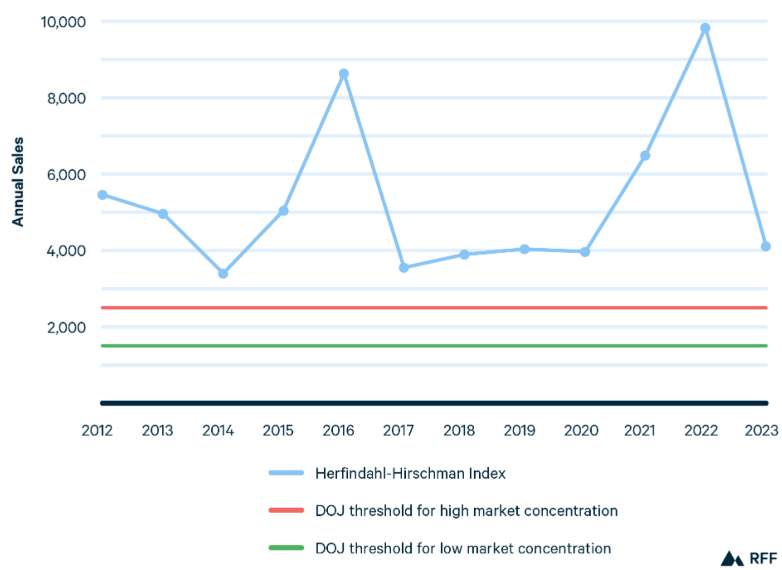
Tesla has been one of the manufacturers that regularly generate excess compliance credits between 2012 and 2023. This manufacturer commonly sells credits to other manufacturers and is currently the largest historical supplier of GHG credits. Through 2023, Tesla sold more than 120 million GHG credits cumulatively, which is more net credit sales than all other manufacturers combined. Many other manufacturers have sold relatively small numbers of credits, which are included in the "Other" category (see the figure notes for a list of these manufacturers). For example, Rivian has sold 1.4 million credits as of 2023.

To assess the degree of market power in the GHG credit market, we compute the Herfindahl-Hirschman Index (HHI) by year. The HHI is a common indicator of market concentration to assess market power. To compute the HHI by year, we convert cumulative credit sales into annual values by taking the difference in cumulative values across consecutive years. We compute market shares of credit sales by manufacturer for those reporting a positive amount of credits sold based on our annual difference methodology. Following HHI calculation methodology, we then multiply market shares by 100 to convert them to values between 0 and 100. Finally, we square these values and take the sum across manufacturers in each year of data.

The results of this calculation appear in Figure 3. The HHI is mathematically bounded between 0 to 10,000. A value of 0 represents perfect competition and a value of 10,000 represents pure monopoly power with a single firm. The US Department of Justice and Federal Trade Commission (DOJ and FTC 2010) define three types of market concentrations based on calculated HHI:

1. HHI below 1,500 is an unconcentrated market,
2. HHI between 1,500 and 2,500 is a moderately concentrated market; and,
3. HHI above 2,500 is a highly concentrated market.

Figure 3. GHG Credit Market Concentration: Herfindahl-Hirschman Index, 2012–2023



Source: The data in figure 3 are collected from 2012–2016 Greenhouse Gas Emissions Standards for Light-Duty Vehicles Manufacturer Performance Reports and 2018–2024 EPA Automotive Trends Reports.

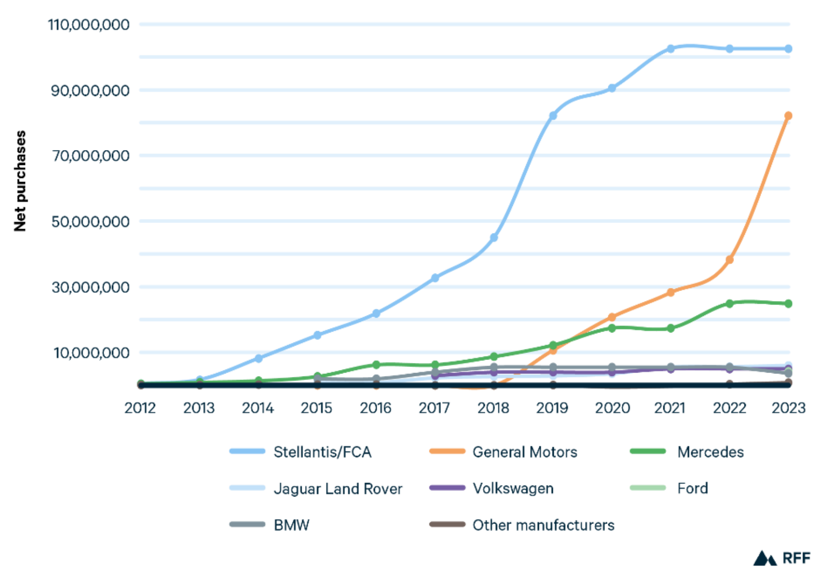
Note: The Herfindahl-Hirschman Index (HHI) is computed by first converting cumulative credit sales based on data from Figure 2 into annual values by taking the difference in cumulative values across consecutive years. Market shares of credit sales by manufacturer are computed for manufacturers reporting a positive amount of credits sold based on our annual difference calculation. The market shares are then multiplied by 100. These values are then squared and summed across manufacturers in each year to define the HHI values.

Figure 3 includes lines that represent the two thresholds: a) HHI at or below 1,500 and b) HHI above 2,500. The HHI calculated based on credit sales indicates that the GHG credit market has been highly concentrated in every year of trading data, with all values exceeding the DOJ definition of a highly concentrated market. Furthermore, several notable years indicate extreme market concentration: 2016 had an HHI over 8,000 and 2022 had an HHI close to 10,000. The 2022 HHI value is due to Tesla accounting for nearly all credit sales in that year.

In summary, we find strong evidence that the GHG credits market has experienced substantial market concentration, indicating a high likelihood that manufacturers have exercised market power when selling GHG credits. EPA (2025) and CEA (2020) dismiss the possibility of market power by arguing that over time, the average firm is neither a buyer nor a seller (see footnote 88 of EPA 2025). However, this is a meaningless statement. Standard theory states that the low-cost firms sell to high-cost firms. If certain firms always have lower costs, they will always be sellers. Nothing in theory says that a particular firm will sometimes sell and other times buy. If it turns out that a few firms are always sellers, they will have market power—regardless of the position of the "average firm." If Tesla consistently has lower costs, which they clearly have given their selling behavior, then this manufacturer will consistently have market power.

To illustrate which firms have been buying credits from Tesla, we use the same data that we used to construct Figure 3. Figure 4 shows cumulative net credits purchased by manufacturers with net purchases as of 2023. The figure shows that Stellantis has accounted for a large share of total credit purchases, with over 100 million in cumulative net credits bought by 2023. Prior to 2020, General Motors (GM) and Mercedes were the next largest buyers, having purchased about 20 million credits by 2020 (as compared to about 90 million by Stellantis). Since 2020, GM has purchased more than 60 million credits, which is far more than any other firm. Stellantis and Mercedes are the next two largest buyers, with each of them purchasing roughly 10 million credits. Thus, since 2020, when Tesla was the major seller, GM (and, to a lesser extent, Stellantis) and Mercedes were buyers.

Figure 4. Cumulative net credits bought by manufacturers with net purchases, as of 2023



Source: The data is collected from the 2012–2016 Greenhouse Gas Emissions Standards for Light-Duty Vehicles Manufacturer Performance Reports and 2018–2024 EPA Automotive Trends Reports.

Note: Manufacturers with net sales as of 2023 are those with a negative cumulative balance for credits purchased or sold. Manufacturers in the Other manufacturers category include Astin Martin, Ferrari, Kia, Lotus, McLaren, and Mitsubishi. For 2012–2016, we show data from the Total column of Table 4-1 in each report. For 2017 and 2018, we show data from the Credits purchased or sold column of Table 5.17 in the 2018 and 2019 reports, respectively. For 2019 and 2020, we show data from the Credits purchased or sold column of Table 5.18 in the 2020 and 2021 reports, respectively. For 2021–2023, we show data from the Credits purchased or sold column of Table 5.19 in the 2022–2024 reports, respectively.

Next, we combine economic theory with the RFF equilibrium model of the new vehicle market to quantitatively illustrate how much the CEA approach might overstate actual marginal abatement costs. The model simulates vehicle sales and prices as well as manufacturer fuel economy choices and electric vehicle offerings, given assumptions on regulation, fuel prices, and total vehicle demand (see Leard, Linn, and Springel (2023) for details).

According to the compliance data in Figure 2, Tesla accounts for over 50 percent of net credit sales as of 2023 and virtually all sales siince 2020. Given Tesla's market position, we consider what would happen if Tesla behaved according to standard monopoly pricing theory. As any undergraduate microeconomics textbook would show, a monopolist's price depends on the marginal costs and elasticity of demand (that is, the percent change in demand caused by a 1 percent price increase). If we define the markup as the difference between price and marginal cost divided by marginal cost, the markup equals $-1/\epsilon$, where ϵ is the own-price elasticity of demand. This equation indicates that the more price inelastic demand is (the smaller ϵ is in absolute value), the higher the markup. In this context, the demand elasticity is the percent increase in tax credits generated by vehicles produced in the market, given a 1 percent credit price increase. The higher credit price causes manufacturers to reduce relative prices of vehicles whose emissions rates exceed their targets and make their vehicles more efficient (Leard, Linn, and Springel 2023).

Thus, given data on the credit price and an estimate of the demand elasticity, we can estimate the marginal abatement costs. Note that we cannot use observed credit prices and transactions to estimate the demand elasticity. The reason is that unobserved factors, such as expectations of future standards, may affect equilibrium prices and transactions (that is, the classic simultaneity problem). Therefore, we use the RFF model to estimate the demand elasticity. More specifically, we simulate a baseline scenario that includes inputs from model-year 2022: the GHG standards, aggregate demand for new vehicles, and fuel prices. We use 2022 values of these inputs for consistency with our prior modeling (see Leard et al. 2023 for further details of this scenario). The model predicts equilibrium prices and sales of each vehicle in the market (distinguishing vehicles by model, trim, fuel type, engine size, and body type), as well as the equilibrium credit price.

We compare this scenario with a second scenario that increases the credit price by 1 percent, which causes manufacturers to adjust vehicle prices and fuel economy of their gasoline vehicles. Those manufacturer responses reduce the average GHG emissions rate of vehicles sold, and we compute the elasticity of demand as the percent reduction in emissions given the 1 percent credit price increase. The market-wide demand elasticity is –1.8 (that is, excluding Tesla's response to the hypothetical credit price change). We also compute a demand elasticity specifically for Stellantis, GM, and Mercedes, since they have accounted for nearly all credit purchases since 2020. The demand elasticity for those firms is about –1.4.[6]

These two demand elasticities imply that the marginal abatement costs are 29–44 percent of the credit price. For example, a credit price of $100 per mpg would imply marginal abatement costs of $44 per mpg if the demand elasticity is –1.8. As noted above, we do not model the potential strategic interactions between Tesla and other potential credit sellers, because of which we treat these numbers as illustrative of the point that accounting for market power can substantially reduce estimated marginal abatement costs.

This overestimate is multiplicative with the overestimate discussed above that is caused by using older credit price data. Thus, combining the newer credit price data from the previous section with the market power calculations in this section indicates that EPA (2025) overestimates marginal costs by 80–90 percent. Recall that these estimates are made under the unsupported assumed linearity between marginal compliance costs and the mpg requirement.

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[6] In theory, firms that have not purchased credits in the market can affect the equilibrium price even if the sellers have market power. As a hypothetical example, Tesla may consider the fact that if it increases the credit price, Hyundai may reduce emissions of its vehicles and compete against Tesla in the credit market. Estimating the marginal abatement costs accurately would require modeling such strategic behavior, because of which we treat the values as illustrative.

Replacing the EPA's assumptions with more recent data and accounting for market power reduces costs by a factor of 5–10, and this "revealed preference" methodology is highly sensitive to inputs. For example, EPA (2025) estimates compliance costs of the 2024 standards to be $18,000 per vehicle, compared to the SAFE rule. Using updated credit price data and accounting for market power in the credit market reduces those costs to $1,800–$3,600 per vehicle. For comparison, the EPA estimated costs of the 2021 rule relative to the SAFE rule to be $1,200 per vehicle and costs of the 2024 rule relative to the 2021 rule to be $2,100 per vehicle.[7] Our estimates of the current proposal, relative to the SAFE rule, are thus more closely aligned with prior EPA estimates than with the current ones.

4.3 The assumed linearity between marginal compliance costs and stringency does not account for innovation and recent consumer demand.

The revealed preference analysis uses credit prices to estimate past marginal costs and then extrapolates those marginal costs assuming a linear relationship between the change in MPT and the change in marginal costs. The previous section explained why marginal costs are likely to be less than credit prices. In this section, we put that issue aside and suppose for the sake of argument that the credit price equals the marginal abatement cost for a given level of the standard. Then, assuming that is true, we explain why this approach will overestimate future marginal costs. Note that this conclusion pertains both to the revealed preference approach and the approach that extrapolates past estimates of compliance costs.

First, EPA (2025) asserts that the 2024 standards amount to an electric vehicle mandate (including plug-in hybrids and all-electrics), implying that manufacturers can only comply by increasing the production share of electric vehicles at the expense of gasoline vehicles. In fact, manufacturers have multiple options, such as improving the efficiency of gasoline engines or converting pure gasoline vehicles to strong hybrids (Lovins 2021). By restricting the manufacturers' compliance options, this revealed preference methodology overstates costs, since the restriction amounts to imposing additional constraints on manufacturers (for example, that they cannot sell more hybrids), which increases the estimated costs of the standards if any of those constraints are binding. Klier and Linn (2012) show that limiting the available compliance options causes the analysis to greatly overestimate compliance costs.

Second, extrapolation only works if one knows the slope of the per-vehicle cost function in equation (4) in EPA (2025), that is, the rate at which per-vehicle costs increase with the change in MPT caused by the standards. EPA (2025) does not provide details, but it appears that the slope depends on the substitutability between gasoline vehicles and electric vehicles. As we explain next, two recent changes in the market indicate that this substitutability has likely increased, which would cause the proportionality in equation (4) and the slope in Figure 3 of EPA (2025) to decrease.

The first change is that electric vehicles have increased their market shares steadily since they first entered the market about 15 years ago. Initially, consumers essentially had just two options—the Chevrolet Volt and Nissan Leaf—but options have expanded across manufacturers and market segments, including several all-electric companies led by Tesla. The second change is that conventional (non-plug-in) hybrid sales have increased steadily since around 2020 and now outsell electric vehicles. Conventional hybrids first entered the US market about 25 years ago and through the 2010s, they accounted for about 2–4 percent of total sales. Since 2020, the market share of hybrids has grown roughly 2 percentage points per year and so far in 2025 they represent about 12 percent of total sales. EPA (2025) acknowledges the growth of electric vehicle demand and asserts that its analysis allows for technological progress in vehicle manufacturing by letting MPT increase with time at the same rate under the proposed rule and with no action. This progress may

[7] It is not appropriate to add the 2021 and 2024 per-vehicle cost estimates to one another to arrive at a cost of the 2024 standards relative to the SAFE rule, because modeling assumptions changed between the 2021 and 2024 analyses.

represent changing consumer preferences within the internal combustion engine 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 electric vehicles, or trends in the structure of energy prices (see EPA 2025, p. 50). According to Section 2.6 of the Appendix, EPA (2025) allows for such technological progress based on historical rates of technological progress prior to 2011.

We agree that changes in technology or consumer demand, such as recent changes in electric vehicle and hybrid demand, affect the MPT that would occur in the absence of regulation. EPA (2025) is incorrect, however, that such changes would not affect the slope of the cost function in equation (4). In fact, as we explain next, increasing demand for electric vehicles and hybrids as well as technological progress for electric vehicles would also cause the slope of the cost function to decrease toward zero, reducing estimated compliance costs.

To demonstrate this point, we consider a simplified situation in which manufacturers sell gasoline vehicles and hybrids but not electric vehicles, and that the only way to increase MPT is to increase sales of hybrids relative to gasoline vehicles. In that case, as Callejas et al. (2025) derive, the compliance cost is proportional to the difference in markups between gasoline and hybrid vehicles (the markup refers to the difference between the price and marginal cost of producing the vehicle, net of credit transactions). For example, suppose the gasoline vehicle has a $10,000 per-vehicle markup and the hybrid an $8,000 per-vehicle markup. The manufacturer can increase MPT incrementally by reducing gasoline vehicle production by 1 unit and increasing hybrid vehicle production by one unit. This production shift would reduce the manufacturers' profits by the difference in markups—that is, $2,000 per vehicle. In this situation, an increase in consumer demand for hybrids would likely increase the markup for the hybrid, reducing the cost of shifting production from gasoline to hybrid vehicles. The key mistake in the EPA (2025) analysis is that this increase in demand affects the per-vehicle compliance costs not only by raising no-regulation MPT as EPA (2025) acknowledges, but also by reducing the slope of the cost function, which EPA (2025) ignores.

This example included the simple case in which the manufacturer only has one compliance option—shifting production from gasoline to hybrid vehicles. The conclusion remains the same if there are other compliance options, such as shifting production from gasoline or hybrid vehicles to electric vehicles. An increase in consumer demand for electric vehicles increases the markup for electric vehicles, reducing the costs of shifting production to electric vehicles.

Given time constraints for submitting comments, it is not possible to quantify the effects of growing hybrid and electric vehicle demand on compliance costs of the 2024 standards. Nonetheless, we point out that according to the RFF model discussed above, if consumer demand for hybrids increases sufficiently to double the market size of these vehicles (as has occurred since 2020), markups for hybrids would increase roughly $3,000–$4,000 per vehicle (depending on the vehicle model). This order-of-magnitude calculation indicates that growing demand for hybrids and electric vehicles could reduce compliance costs substantially. A similar argument applies to technological progress that reduces electric vehicle costs, thereby raising markups of those vehicles and reducing the costs of shifting from gasoline vehicles to electric vehicles.

Related to the implications of consumer demand is that EPA (2025) and CEA (2020) note that the higher credit prices from 2012–2016 indicate a low degree of substitutability between gasoline vehicles and EVs. We agree that during that period, there were few electric vehicle options—particularly in popular market segments such as crossovers, SUVs, and pickups—and manufacturers no doubt had to offer large incentives to induce consumers to buy electric vehicles. The mistake the EPA makes is in failing to recognize that in the current market situation—in which many manufacturers have electric vehicle offerings in those popular market segments—consumers appear much more willing to buy electric vehicles rather than gasoline vehicles (Gillingham et al. 2023). This situation increases not only the MPT that would occur in the absence of regulation but also reduces the cost of inducing additional consumers to buy electric vehicles.

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