Comments of the American Council for an Energy-Efficient Economy (ACEEE) on "Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle" (87 FR 17414) Rule"

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The American Council for an Energy Efficient Economy (ACEEE) welcomes the opportunity to comment on the Environmental Protection Agency's (EPA) proposed "Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle" (87 FR 17414) rule. ACEEE is an independent non-profit organization dedicated to advancing energy efficiency policies, programs, technologies, investments, and behaviors. ACEEE aims to build a vibrant and equitable economy, one that uses energy more productively, reduces costs, protects the environment, and promotes public health and safety. Our comments are focused on the greenhouse gas (GHG) components of the proposal, but ACEEE supports limiting nitrogen oxides (NO_x) emissions as much as possible to protect the health of our communities. If EPA has any questions, please do not hesitate to contact ACEEE's Dr. Avi Mersky, at amersky@aceee.org.

EPA must act to limit both NO_x and CO_2 emissions

The United States will need to greatly reduce heavy-duty vehicle (HDV) greenhouse gas (GHG) emissions if it is to stave off the worst impacts of climate change. It must also take significant action to reduce the human health impacts of HDV pollution from criteria air pollutant such as nitrogen oxides (NO_x), sulfur oxides (SO_x), and particulate matter (PM). EPA derives its obligation and authority to regulate HDVs from the Clean Air Act which identifies vehicle emissions standards as a means to protect public health and welfare[i].

Transportation is now the largest source of greenhouse gas emissions in the United States[ii] and heavy-duty vehicles, despite being just 5% of the on-road fleet, are responsible for 31% of on-road energy use, accounting for a similar share of on-road GHG emissions[iii]. This equates to a full quarter of the transportation sector's energy usage and GHG emissions[iv] and more than 6% of total U.S. GHG emissions, making any improvement highly significant[v]. Heavy-duty vehicles also represent a large share of the transportation sector's NO_x, SO_x, and PM pollution. These emissions lead to localized air pollution and the associated health impacts, such as increased rates of asthma, increased risk of heart attacks or strokes, and lung cancer[vi]. These impacts are particularly bad in low-income communities and

communities of color, which bear a disproportionate air pollution burden[vii]. This public health threat is amplified by the fact that more than 230 million Americans — 2/3 of the U.S. population — live in areas impacted by unhealthy heavy-duty vehicle emissions[viii].

ACEEE supports EPA in its effort to limit NO_x emissions as much as possible to protect the health of our communities. However, our comments are focused on the GHG components of the proposal as global climate change remains a major economic and national security threat. After a year of severe forest fires and flooding, EPA cannot miss an opportunity to make significant progress on emission reductions. The stringency and structure of these standards will have lasting impacts as they will determine which vehicles will be sold and used on the road for decades to come, and will also set the baseline that the upcoming Phase 3 standards will start from. It is therefore crucial that EPA gets these standards right. Reducing carbon emissions is critical to tackling climate change but increasing HDV efficiency will also have significant benefits to air quality and reduce fueling costs for our nation's trucks and delivery vehicles, costs that are passed onto the consumer in the form of higher prices for their everyday goods and groceries. Stricter GHG limits for heavy-duty vehicles will also decrease oil consumption. This is key to supporting vital US security interests including moderating oil prices and ensuring a stable oil supply for the US and allied nations.

EPA must improve its projections of EV sales and their implications for stringency

In the original Phase 2 rulemaking EPA projected no EV sales and noted that the model year (MY) 2027 standards were achievable with improvements in internal combustion vehicle (ICV) technology alone. However, EV sales and developments in EV technology have grown rapidly since the rule was adopted and these changes have the potential to significantly decrease the GHG benefit of the rule, by allowing ICVs to lag in performance, or even backslide. Thus, EPA should increase rule stringency to deliver at least the same improvements in ICVs as the original rule expected to deliver, while considering the emissions reduction benefits of an increase in EV market share. Increasing the stringency of the proposed rule by the expected EV market share will not only prevent unnecessary losses in GHG reductions but also preserve manufacturer freedom to choose between ICV improvements or even faster electrification to comply with the rules.

PROJECTIONS OF VOCATIONAL AND TRACTOR EV SALES IN THE PROPOSAL ARE TOO LOW.

In the proposed rulemaking EPA projects that EVs will reach 1.5% of the combined vocational and day cab markets in 2027 (p.17601)[1]. This projection is based upon heavy-duty sales data that shows that California accounts for 3.1% of the national HDV market[2] (p17600-17601), Advanced Clean Truck (ACT) rule requirements and assumptions on California's share of the total EV market[ix] (p.17601).

The adoption of the ACT rule in additional states will have a significant effect on the heavy-duty EV market. To date this rule has been adopted by 6 states[x] and is in the process of being adopted in Connecticut[xi]. Based on EPA's California sales projection and these states' own analyses of the ACT rule, ACEEE estimates that the states that have already adopted the ACT represent at least 6% of the HDV sales market (see Appendix A).

Given these market shares, ACEEE estimates that required EV sales in the states that have already adopted the ACT will account for at least 1% of all HDV sales nationally in MY 2027. Additionally, as the NPRM analysis rightly anticipates (p.17601), the ACT rule will also spur EV sales outside of ACT adopting states, albeit at a slower rate. Assuming that EV sales share in non-ACT states is at least 15% of that of ACT states, EV sales will be 3.5% nationally at a bare minimum in MY 2027. The 1.5% EV sales share in the NPRM underestimates the EV market share by more than a factor of 2 and, therefore, fails to take advantage of the emissions reductions made possible by growing EV sales, potentially allowing ICVs to improve at a slower rate than intended under the Phase 2 standards.

EPA requests comment on additional increases in stringency for 2028 and 2029, correctly noting (17419) that there is information to support higher HDV EV share in those years. ACT requirements will increase to 40% for class 4-6 vocational vehicles, and 25% for class 2b-3 and all class 7-8 vehicles, in MY 2029[xii], and consequently the EV share in ACT states will account for 3% of the HDV market by MY 2029. Continuing to increase stringency through MY 2029 is vital to setting the stage for the next round of rule making, especially given the rapid growth in EVs that is expected in these years. Neglecting to increase stringency during these years would lower the baseline for standards in MY 2030 and lead to a growth in credits that would hinder the adoption of appropriately stringent standards. ACEEE projects

[1] All page numbers refer to this rules NPRM, unless otherwise noted.

[2] As discussed further below, however, we find this to be an implausibly low market share for California.

national EV sales in MY 2029 of no less than 6.5%. Estimated nationwide EV sales are summarized in Table 1.

Table 1 : Minimum Expected Nationwide Heavy-Duty EV Sales

Model Year	EV HDV Market Share (%)
2027	3.5
2028	5.0
2029	6.5

Importantly, California's projected 3.1% share of national heavy-duty sales in 2027 shown in the EPA proposal (p. 17600) is surprisingly small. California HDV registrations accounted for 10% of national tractor registrations in 2020[xiii]. We understand that California's share of HDV sales does in fact trail registration share, but the disparity shown in the NPRM figures is very large. Furthermore, the dollar value of medium- and heavy-duty vehicle sales in California was 6.9% of the national total in 2021[xiv]. Given that California EV sales were calculated as a fixed (ACT-mandated) percentage of all heavy-duty sales in California, low heavy-duty sales projections would result in an underestimate of EV sales. This concern is compounded by the fact that several ACT states scaled their sales to California's reported sales based on truck VMT. Using the states' calculations from their rule adoptions as discussed above leads to the conclusion that the non-California ACT states account for about 3.5% of the HD market, when one would expect them instead to account for 12% based on statistics such as registrations[xv]. Given that the NPRM's own analysis of EV sales is based upon scaling California's projected sales to its share of EV registrations (p.17601), it is worth noting that only looking at registrations would instead lead to nationwide EV sales of 5% in MY 2027.

California is also in the process of adopting the Advanced Clean Fleets (ACF) rule, which will enforce a Zero-Emission Vehicle (ZEV) mandate on fleets operating in the state[xvi]. This rule will create a ZEV mandate for many new vehicle registrations, preventing non-compliant out of state vehicles from being registered in California. This will likely bring California's share of sales closer to its share of registrations and affect the projection of EVs as a percentage of the national heavy-duty market in 2027. Thus, it is crucial that EPA base its EV projections for the final rule on consistent, up-to-date data on state heavy-duty vehicle markets.

THE PROPOSED INCREASES IN VOCATIONAL AND TRACTOR STRINGENCY DO NOT PROPERLY REFLECT THE EPA'S PROJECTED EV SALES SHARE.

EPA proposes to increase GHG emissions stringency by 1.5% for MY 2027 vocational vehicles and day cab tractors based on its projection of 1.5% EV sales share among these vehicles in MY 2027. EPA, however, proposes an exclusion that carveout that reduces this stringency by half. EPA excludes spark ignition (SI) vocational vehicles from the increase in stringency, proposing that all vocational EVs be certified under the compression ignition (CI) standard, while noting that SI and CI vocational vehicles belong to the same averaging set. However, strengthening standards by 1.5% for only a subset of vehicle types fails to reflect the emissions benefits gained by the 1.5% EV sales share that EPA projects across all vocational vehicles and day cabs. SI vehicles account for 60% of class 4 vocational vehicles, and more than 30% of class 5 and 6 vehicles[xvii]. As a result, applying the proposed improvements to just the CI vehicles effectively halves the stringency increase for vocational vehicles to under 1% on average.

If EPA excludes SI vehicles from stringency increases in the final rule, the standards for CI vehicles must be strengthened further to account for the SI market share of each vehicle class. This requires projecting the CI/SI sales split into the future and considering how electrification may change this split. ACEEE recommends that EPA instead increase emission stringency for both SI and CI vehicles, which avoids the need to correct for SI market share. This stringency increase should also be tailored to expected EV sales, which we have already noted is currently underestimated in the proposal. The stringency increase for both CI and SI vehicles, therefore, should not be under 3.5%.

THE PROPOSED STRINGENCY INCREASE INAPPROPRIATELY EXCLUDES CLASS 2B –3 VEHICLES.

EPA does not propose any changes in Class 2b-3 vehicle emission standards, nor do they provide evidence that these vehicles are less likely to be electrified over the life of the rule. As of this point in time GHG emissions from Class 2b-3 pickup trucks and vans are regulated under the heavy-duty standards alone. EPA has discussed potentially regulating these vehicles as light-duty vehicles (P. 17417), however there are no proposals on the table to do so yet. EPA should include them in any and all rule updates. Excluding them without reason misses the opportunity and the need to hold them to more appropriate standards. Should EPA decide to include these vehicles in future LD regulations, they can then amend the HDV regulations accordingly.

EPA should use the rule to push technological development

Until this point, our comments have focused on improving EV sales projections and the corresponding stringency increases, and ensuring that the rule does not allow ICV performance to degrade. The Phase 2 GHG emission program, however, is meant not merely to reflect real-world technological trends, but to push them further to achieve greater GHG reduction. Simply updating EV sales estimates and rule stringency to recognize current state commitments to vehicle electrification, will not push developments in ICV technology or EV sales as far as feasible or as fast as needed to meet broader climate goals.

In addition to the states that have already adopted the ACT rule, 10 other states are parties to a Memorandum of Understanding committing to rapid electrification of heavy-duty vehicles. Strong federal standards would help encourage these states to adopt the ACT, which would push the market further and set the stage for stronger standards in MY 2030 and beyond.

Likewise, many manufacturers have announced accelerated schedules for heavy-duty EV production, with several companies announcing targets of 50% worldwide electrification by 2030, including Volvo and Scania[xviii]. Vehicle standards of comparable ambition would provide crucial support for these leading companies and ensure that their targets can be met in the U.S. market.

Historically, EPA has developed proposals for vehicle standard stringency using analysis of technology cost-effectiveness, among other considerations. Yet no up-to-date analysis of heavy-duty EV ownership cost parity appears in the proposal. A recent National Renewable Energy Laboratory (NREL) study found that EVs will make up 42% of the medium-duty (MDV) and HDV market share by calendar year 2030, based on a lower total cost of ownership for more EV types[xix]. This finding suggests that EPA could feasibly set standards that decrease emissions in new vehicles by 20% in MY 2027 and linearly increase to 40% in MY 2029, compared to the current standards; either by increased EV sales or even greater improvement to ICV performance. This is supported by the NREL study, which predicts that many EVs will become cost competitive by MY 2027[xx]. The NREL study additionally suggests that EVs could rapidly grow in cost performance and market share even as ICVs continue to improve efficiency, undercutting arguments that one must come at the expense of the other[xxi]. This rate of electrification is also roughly consistent with the ACT requirements, supporting EPA standards consistent with the year-by-year EV sales shares required by the ACT on a nationwide basis.

Such ambitious actions are necessary to deliver the progress on ICV efficiency and EV adoption to meet broader climate goals. Global warming is a critical threat to our nation and we need to limit the increase in global average temperatures to less than 2°C. Research from the International Council for Clean Transportation (ICCT) suggests that mild increases in rule strigency are not enough to have an impact. Accounting for the fact that vehicles sold today will remain on the roads for over a decade, and their GHG emissions much longer, HD ZEV sales must reach at least 20% in MY 2027 and 50% in 2030%[xxii]. ICCT's estimates are summarized by vehicle class and type in Table 2. These sales numbers are excedingly close tolevels that NREL and industry actions suggest are possible. For this reason ACEEE suggests that EPA increase average strigency by 19% in MY2027 and increase this linearly to 40% in MY 2029.

Table 2: Minimum Fleet-Average Sales Share of EV HDVs in the United States[xxiii]

	MY 2027	MY 2028	MY 2029	MY 2030
Buses	40%	60%	80%	100%
Class 4-8 rigid	20%	30%	40%	50%
Class 7-8 tractors	15%	20%	25%	30%
Fleet Average	19%	30%	40%	46%

EPA should eliminate the Advanced Vehicle Technology Credits as quickly as possible

The Advanced Vehicle Technology Credit endangers the emissions reductions from the standards, even with proposed stringency increases, and should be eliminated as quickly as possible. This credit was planned for a much less mature EV market than we have now. Based on currently expected EV sales, the credits would allow substantially worse fleetwide GHG performance than the nominal stringency of the Phase 2 standards would indicate.

Table 3 shows the effects of the existing credit on the current and proposed rule stringencies for class 4-5 light heavy-duty vocational vehicles[3], which saw their effective stringency changed the least as a result of increased rates of electrification, and therefore represent a conservative estimate of the potential loss in stringency resulting from the credits. The methodology ACEEE used to arrive at these estimates is explained in Appendix B. As the table shows, even with the lowest plausible EV sales shares in 2027, the existing advanced technology credits would lead to effective standards far weaker than the nominal Phase 2 standards for MY 2027, with effective emissions limits for ICEs lower than even the MY 2021 standards. Figure XI-1 of the NPRM quantifies this in terms of emissions and shows that the minimum expected nationwide EV sales would result in an increase of over 30,000,000 Mg of GHG emissions.

Table 3: Effects of Minimum Expected EV Sales on Rule Stringency with Advanced Vehicle Technology Credit

Vehicle Class	MY 2021 Emission Limit	MY 2027 Emission Limit (Original Rule)	MY 2027 Emission Limit (EPA Proposal)	MY 2027 Effective ICV Emission Limit	MY 2027 Effective Fleetwide Emission Limit
Light heavy-duty (Urban) (gCO2/ton-mi)	424	367	361	429	413
Light heavy-duty (Multi-purpose) (gCO2/ton-mi)	373	330	325	385	372
Light heavy-duty (Regional) (gCO2/ton-mi)	331	291	286	340	328

[3] The division between light heavy-duty vocation vehicles is different in the ACT sale requirements and federal emission rules. This table ignores any averaging between Light Heavy-Duty vehicles which have different ACT sale requirements.

EPA requested comment on three options to limit these adverse effects of this credit. ACEEE believes option 3, the complete phase-out of the credit by MY 2027, is the best of the options offered to mitigate the harm of the credit and ensure continued improvement in ICVs, as shown in Table 4. However, option 3 alone would be insufficient to address the problem. We suggest that EPA also exclude any vehicle certified for ACT compliance and sold in any ACT adopting state, from eligibility for this credit, effectively combining proposed options 1 and 3. This will ensure that manufacturers' compliance with state regulations does not result in reduced emissions benefits of the federal rule.

Table 4: Effects of Minimum Expected EV Sales on Rule Stringency Assuming Option 3

Vehicle Class	MY 2021 Emission Limit	MY 2027 Emission Limit (Original Rule)	MY 2027 Emission Limit (EPA Proposal)	MY 2027 Effective ICV Emission Limit	MY 2027 Effective Fleetwide Emission Limit
Light heavy-duty (Urban) (gCO2/ton-mi)	424	367	361	388	374
Light heavy-duty (Multi-Purpose) (gCO2/ton-mi)	373	330	325	348	336
Light heavy-duty (Regional) (gCO2/ton-mi)	331	291	286	307	297

Recommendations

EPA has rightly proposed to strengthen MY 2027-2029 GHG and NO_x emissions regulations. However, the rule needs improvements. As discussed, the rule does not follow the historical standard of using technology cost-effectiveness analysis to set stringency and instead simply attempts to follow market trends. In doing so it also significantly underestimates the pace of technological development. The proposed rule is also weakened by counterproductive credit

provision and vehicle exclusions. Even without these credits and exclusions the proposed rule is not stringent enough to ensure the predicted improvements in ICV efficiency. Moreover, a much stronger rule is needed to support an EV adoption trajectory consistent with the cost-effectiveness of electrification in a rapidly growing number of heavy-duty vehicle segments and the urgent need to curtail transportation greenhouse gas emissions. While our comments are focused on the GHG portion of the NPRM, ACEEE also recognizes the value and pressing need to reduce NO_x and other criteria pollutant emissions as much as possible. ACEEE encourages EPA to ensure that the final rule protects the health of our nation by ensuring that the final rule pushes NO_x standards and technology further than what the current market can support and drives innovation. ACEEE proposes the following recommendations for the final rule.

- EPA should improve its EV sales estimates to reflect consistent, up-to-date data on state heavy-duty vehicle markets. Reference case EV sales estimates of at least 3.5%, 5%, and 6.5% in MYs 2027, 2028, and 2029, respectively, are warranted. GHG stringency increases of these same percentages would be required just to ensure that the ICV improvements in the original rule are preserved.
- EPA should not exclude vehicles that will see significant electrification, such as class 2b-3 pickup trucks and vans, from stringency increases and should, likewise, not exclude SI vehicles.
- EPA should set standards that reflect an EV share of 19% by MY 2027, 30% in MY 2028, and 40% in MY 2029. This is also in line with the pressing need to prevent global temperatures from rising more than 2°C.
- EPA should both phase out the Advanced Vehicle Technology Credit program, by MY 2027, and also immediately exclude any vehicle certified for compliance with the Advanced Clean Truck Act, and sold in an adopting state, from eligibility for this credit.

EPA's medium- and heavy-duty vehicle emission standards are a vital tool to protecting vehicle owners, the environment, and the public. Standards that push technology forward help consumers save on fuel costs, reduce environmental damage, and reduce dangerous pollution that increases the risk of breathing-related illness. ACEEE believes that EPA has built a good framework in this proposed rule, but believes it needs to be more ambitious to reflect the White House's new goals for emission reductions by 2030 and EV market development. ACEEE thanks EPA for the opportunity to contribute these comments and improve the final rule.

Appendix

A. MARKET SHARE AND EV SALE PROJECTIONS

We estimated national EV market share based on assumed compliance with ACT requirements. States were divided between those that have already adopted the ACT and those that have not. States that have already adopted the ACT rule were grouped together as the "Current ACT States". These states include California, Massachusetts, New Jersey, New York, Oregon, Washington[xxiv]. All other states were identified as "Non-ACT States". We estimated the market share of each of the ACT states to calculate the market share of each set of states. "Non-ACT States" was estimated as holding the remaining market share.

State Market Share Projections

State market share was either taken directly from this NPRM, state ACT adoption regulatory documents, or, in situations where neither was available, using methods consistent with those states that shared their HDV sale estimates in their ACT adopting regulatory documents. As most states applied scaling factors, comparing themselves to California, we computed each state's market share as a percentage of California's. Several states used an ICCT report[xxv] in their calculations of their state's EV MDV/HDV sales. This report was used for states that did not provide an independent estimate and was compared to California's own estimated MDV/HDV sales, from the ACT's Regulatory Impact Assessment (RIA)[xxvi]. If sources provided a range of possible scaling factors, we applied all to find a range of possible market shares.

California

California's HD market share was taken from this NPRM, estimated at 3.1% of the market for regulated vehicle sales. For comparison to other states, we took CA's sales from the ACT's RIA[xxvii], estimated MY 2030 MD/HDV sales at 79,032.

New Jersey

New Jersey, in its proposed rule to adopt the ACT[xxviii], applies a scaling factor based on California and medium- and heavy-duty VMT for New Jersey trucks. This scaling factor is 0.150, or 15% of California's sales.

Massachusetts

Massachusetts does not directly state their estimated sales but notes that they calculated them, and associated EV benefits[xxix], based on reported sales from the ICCT report[xxx]. This report notes Massachusetts' EV sales from the ACT as being 3,557 in 2030, or MY 2029. ACT

requires, depending on vehicle class, 30-50% EV sales[xxxi]. This leads to total MD/HDV sales of between 7,100-1,200 in 2030, or between 9%-15% of California's sales.

New York

New York, in most areas of its RIA including vehicle sales, applies a scaling factor of .32 to the results published in California's ACT RIA; in other areas the state uses the aforementioned ICCT report[xxxii]. We directly took the .32 scaling factor.

Oregon

Oregon used multiple sources, including the ICCT report, to determine a scaling factor[xxxiii]. While they do not share the exact methodology, they find total GHG reductions between 2020-2440 to be between 1.8 MMT and 2.4 MMT, compared to CA's 9.6 MMT CO2e. This leads to a scaling factor of between .18-.25.

Washington

Washington, being required by statute to adopt the ACT, did not run an RIA or provide sale estimates that could be compared to California's[xxxiv]. We calculated a scaling factor using the ICCT report[xxxv], using the same method as in MA. ACT EV sales in 2030 were estimated to be 8,169, which leads to total MD/HDV sales of 16,000-27,000, or between 21%-35% of California's sales.

Current ACT State Market Share

Using our scaling factor estimates we estimated high and low ranges for this group's total market share.

$$.031 * (1 + .15 + .09 + .32 + .19 + .21) = 6.1\%$$

$$.031 * (1 + .15 + .15 + .32 + .25 + .35) = 6.9\%$$

EV Sale Projections

EV sales were projected based on assumed compliance with the ACT for each state grouping. This varied by scenario. The assumed compliance for each scenario and state group is summarized in Table A1. ACT required EV sales are summarized in Table A2. For each model year, each group's market share range was multiplied by its compliance level and the required percentage of EV sales by model year. The low end of our EV sales projections, in each scenario and model year, uses the ACT sales requirements for class 2b-3 and 7-8 vehicles, the upper end estimate of non-MOU states' market share, and the lower end estimate of MOU states, current ACT States and adopting ACT states market share. The higher range used the sales requirements of class 4-6 vehicles, the lower estimate of non-

MOU states' market share, and the higher estimate of MOU states, current ACT States and adopting ACT states market share. The results from this analysis are summarized in Table A3. In the main text of our comments, we use the midpoint of these findings and round to the nearest ½%. Given the much higher sales share of vocational vehicles, as compared to tractors, we expect this to be somewhat conservative.

Table A1: EV Sales Scenarios

Group	% ACT Compliance, Only ACT Scenario	% ACT Compliance, Minimum Expected Scenario
Current ACT States	100	100
Non-ACT States	0	15

Table A2: ACT Required EV sales by Vehicle Class

MY	Required % EV sales Class 2b-3, 7-8	Required % EV sales Class 4-5
2027	15	20
2028	20	30
2029	25	40

Table A3: Estimated EV sales %

MY	Only ACT Scenario (% national EV Sales)	Low Scenario (% national EV Sales)
2027	0.9-1.4	3.0-4.2
2028	1.2-2.1	4.0-6.3
2029	1.5-2.8	5.1-6.7

B. ADVANCED VEHICLE TECHNOLOGY CREDIT PROGRAM EFFECT ESTIMATES

The Advanced Vehicle Technology Credit program awards each EV sold with credits as if it were 4.5 zero emission vehicles. This section of the Appendix describes how the effect of this provision on actual rule stringency was estimated. We calculated 1) the average stringency required for ICVs, if every earned EV credit was used in the year that it was earned; and 2) the effective fleetwide stringency.

For both of these we first needed to calculate the effective size of the pool of credits earned, compared to the actual number of vehicles sold. This was calculated as $= 1 + EV\ Share * (EV\ Multiplier - 1)$. This was then used to compute the "effective" EV share, $= \frac{EV\ Share * EV\ Multiplier}{Effective\ Credit\ Pool}$. This shows us the effective number of EVs that the rule accounts for in compliance, given that each EV counts as multiple EVs.

CI class 4-8 vehicles are also subject to engine standards, which the 2017 rule updated. SI vehicles are subject to engine standards that have not been updated from the Phase 1 rule. Class 2b-3 vehicles have no engine standards. Engines are not subject to the Advanced Vehicle Technology Credit program. While engines do not alone define vehicle performance, we assumed that engine standards would still limit any potential stagnation or backsliding in total vehicle performance, regardless of the number of credits available.

We assumed that, regardless of the number of credits in circulation, a CI vehicle would need to increase in performance in proportion to at least half the stringency of its engine standards. In other words, if a vehicle's engine was required to reduce emissions by 4%, compared to MY 2017, that vehicle must improve at least by 2%, over the same time frame. Most CI engines required a performance increase of about 4-5% between MYs 2017-2027. Given that SI engines did not face increased stringency requirements we assumed that they could decrease, from the MY 2017 stringency, by a similar magnitude. That is, we assumed that SI class 4-8 vehicles could decrease by no more than 2% from MY 2017 standard levels. Class 2b-3 vehicles, not being subject to any engine standards, did not face any such limitations.

ICV performance was calculated as $= \frac{MY\ Target}{1 - Effective\ EV\ Market\ Share}$. Should ICV performance decrease more than the engine standards would allow, as described above, then the vehicle was assumed to change in performance in proportion to the engine standard. For CI vehicles this was half the percentage improvement required in the engine standard. For SI vehicles this was a decrease of 2% of the 2017 standards. Class 2b-3 vehicles were uncapped.

Fleetwide performance was calculated as $= ICV\ Performance * (1 - Actual\ EV\ Market\ Share)$.

For the Status Quo scenario the multiplier was 4.5 and for the Option 3 scenario the multiplier was 1.5.

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