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May 23, 2019

Attention: NHTSA Docket ID No. NHTSA-2018-0067
U.S. EPA Docket ID No. EPA-HQ-OAR-2018-0283

Re: Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021-2026 Passenger Cars and Light Trucks

Dear Mr. Lieske and Mr. Tamm:

I am the President of H-D Systems, a Washington-based consulting firm specializing in automotive technology, emissions, and fuels. I previously submitted comments in October 2018 and April 2019 at the request of the California Department of Justice on behalf of the California Air Resources Board (CARB).[1] The Alliance of Automobile Manufacturers (Alliance) submitted a supplemental comment dated April 19, 2019 that addresses my October 2018 comment.[2] Nothing in the Alliance's supplemental comments changes the conclusions in my original comments that EPA's and NHTSA's (Agencies') analysis in the 2016 Draft Technical Assessment Report (Draft TAR) and EPA's analysis in its Technical Support Document for the Proposed Determination (2016 TSD) of the existing standards' costs of compliance remain appropriate. Moreover, the Alliance's supplemental comments highlight additional errors and discrepancies in the Agencies' analysis of the proposed rule beyond what I had identified in my October 2018 comments. Therefore, I am submitting this supplemental comment containing material "of central relevance to the rulemaking" (42 U.S.C. § 7607(d)(4)(B)(i)) to clarify the record.

The Alliance submitted its comments six months after the comment deadline. According to the Alliance, "it was not possible to provide [its] supplemental comments at an earlier time," because the Alliance had "to attempt identification of many of the sources and references on which [my] submission claims to have been based, and then [had] to respond to the submission with current information."[3] That the Alliance found it impossible to respond to my comment in

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[1] K. Gopal Duleep, Review of the Technology Costs and Effectiveness Utilized in the Proposed SAFE Rule, October 2018, Docket No. NHTSA-2018-0067-11985, EPA-HQ-OAR-2018-0283-6475 ("Initial H-D Comment"); K. Gopal Duleep, April 29, 2019 Supplemental Comment, Docket No. NHTSA-2018-0067-12389, EPA-HQ-OAR-2018-0283-7457 ("Supplemental H-D Comment").

[2] Alliance of Automobile Manufacturers Supplemental Comment, April 19, 2019, Docket No. NHTSA-2018-0067-12385; EPA-HQ-OAR-2018-0283-7455 ("Alliance Supplemental Comment").

[3] Alliance Supplemental Comment, cover letter.

less than half a year highlights the inadequacy of the public comment period for the proposed rule. The Agencies provided the public only sixty-three days to analyze and respond to hundreds of pages of technical information and thousands of lines of model files, inputs, and outputs. Especially in that context, some of the Alliance's comments are trivial: that I omitted a citation, used abbreviations that the Alliance perceives as unclear, and presented technology costs in nominal rather than real dollars. Although I have made some minor corrections to the data in my earlier analysis, the Alliance's comments do not change my ultimate conclusion that the Agencies exaggerated the cost of meeting the existing standards in the 2018 SAFE proposal.

In addition, the Alliance's supplemental comment highlights that much of the material in the Preliminary Regulatory Impact Analysis (PRIA) and Volpe model files is opaque at best. For example, the Agencies did not provide an accurate, comprehensive list of technology cost and effectiveness estimates underlying their calculations in the PRIA, forcing commenters to debate which values the agencies actually used, rather than discussing whether those values were valid representations of the real world.[4] As a result, the Alliance critique focuses extensively on establishing what specific cost and effectiveness estimates the Agencies actually used in their analysis, and not on what cost or effectiveness estimates the Agencies should use.[5]

The timing of Alliance's submitting its supplemental comments—a half year after the conclusion of the comment period and a matter of weeks before the reported June target for the Agencies' final action[6]—once again leaves me inadequate time to respond. To ensure that the Agencies have the benefit of my responses before issuing any final rule, I have performed an expedited review of the Alliance's comment, and have necessarily limited that review to only certain of the Alliance's contentions. However, the fact that time constraints leave me unable to respond to every comment does not mean that I agree with them or that they are valid. Rather, I remain confident that the conclusions in my original report are accurate.

This comment primarily addresses three methodological topics and three data-related topics. On the methodological side, I first clarify issues related to the Agencies' failure to correctly model vehicle redesign cycles. Second, I show that the Agencies' modeling improperly limited the efficiency of technologies that reduce tractive load. Third, I demonstrate that EPA's lumped parameter model (LPM), which I cite throughout my original comment, has consistently withstood the Alliance's criticism.

On the data side, I first explain that the Agencies erred when they excluded next-generation Atkinson technology as a compliance option in the Volpe model. Second, on mass reduction, I note that the Alliance does not respond to my analysis that the Agencies erroneously

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[4] In fact, I understand that CARB has filed a Freedom of Information Act lawsuit seeking clarifying information.

[5] *See* Alliance Supplemental Comment, at 38-47 (almost exclusively arguing about which values the Agencies used in their analysis); *id*. at 56 ("Costs provided herein are based solely on the Agencies' and other third-party analysis as noted. Unless otherwise noted, the Alliance makes no claim to the accuracy or the applicability of these costs to any particular vehicle, vehicle type, or similar.")

[6] *See* Alex Guillén, "Wheeler says auto rule coming 'spring or early summer,'" *Politico Pro* (Apr. 4, 2019)

limited glider weight, and I establish that the Alliance committed a crucial error in its calculation of mass reduction costs. Finally, I show that the discrepancies the Alliance alleges between my tabulation and the Alliance's estimate of certain electrification costs were actually caused by inconsistencies in the Agencies' PRIA tables.

*The Alliance Does Not Address the Central Issues with the Volpe Model's Implementation of Redesign Cycles.*

In my initial comments, I noted that engine and transmission changes frequently occur outside of redesign years, contrary to the Volpe model's requirement that engine and transmission changes occur only in redesign years.[7] This requirement in the Volpe model incorrectly limits the rate of new engine and transmission technology penetration. The Alliance attempts to undermine this observation by challenging my determinations as to when technology adoption occurred in my three examples: the Chevrolet Malibu, Ford F-150, and Jeep Grand Cherokee. The Alliance's discussion proves my point: the Alliance's supplemental comment shows most new engine and transmission introductions (all transmission changes on the Malibu and virtually all engine and transmission changes on the F-150) occurring outside of redesign years[8]—something that the Volpe model prohibits. While manufacturers may in some instances make engine and transmission changes simultaneously in a redesign year, there is obviously no absolute requirement in the auto industry to limit these changes to redesign years. The Alliance's supplemental comment even admits that "engine and transmission development is not necessarily tied to vehicle redesign cycles," and that it "is not overly surprising" that "technologies are not added exclusively at a vehicle redesign or refresh year."[9] The Volpe model rule limiting engine and transmission changes to redesign years is contrary to observed facts.

Nevertheless, the Alliance defends the model's constraint on technology deployment by asserting that it "balances the uncertainty of exactly when fuel economy technologies will be added with the more certain expectation that fuel economy technologies will not be added to a given vehicle every year, and that more changes are likely to occur in a vehicle redesign or refresh year than in other years."[10] But the Alliance's own data contradicts its assertion. For example, the Alliance notes that fuel economy technology was or will be added to the F-150 every year from 2015 through 2020.[11] I also stated in my initial comments that the Agencies must model what the auto industry *can* actually do versus what the industry may choose to do.[12] The Alliance's supplemental comments demonstrate my point—the Alliance notes that manufacturers may "leapfrog" cost-effective technologies in favor of more costly technologies that the manufacturers perceive to have longer-term benefits (due to, for example, zero emission vehicle mandates in other countries).[13] The Alliance thus concedes that manufacturers' observed behavior does not necessarily reflect technological feasibility or cost-effectiveness. In the case

[7] *See* Initial H-D Comment, at 36.
[8] *See* Alliance Supplemental Comment, at 17-22.
[9] Alliance of Automobile Manufacturers Supplemental Comment, April 19, 2019, at 21.
[10] Alliance Supplemental Comment, at 17.
[11] Alliance Supplemental Comment, at 21.
[12] Initial H-D Comment, at 32.
[13] Alliance Supplemental Comment, at 15 n.49.

of refresh and redesign rates, that manufacturers may choose to "most heavily fund"[14] vehicles at a refresh or redesign year is irrelevant to the question of whether manufacturers *can* implement vehicle changes outside of those years.

Finally, I explained in my initial comments that the Agencies' estimate of redesign cycle length was upwardly biased.[15] The Agencies' analysis of historic redesign cycles improperly included models that were eking out a few extra years of life before discontinuation (when the economic incentive to invest in vehicle updates is very reduced or eliminated), and it covered the 2009-2011 financial crisis period where two major auto manufacturers declared bankruptcy and thus reduced capital spending. If these outliers are excluded, the average redesign cycle will be between 5 and 6 years. The Agencies should impose this redesign cycle length as a uniform assessment of what manufacturers can do.

*The Agencies' Modeling Does Not Capture Adjustments That Auto Manufacturers Make to Obtain the Full Benefit of Tractive Load Reductions.*

In my October 2018 comments, I explained that the Agencies incorrectly limited the efficacy of technologies that reduce tractive load because their modeling does not re-optimize engine performance after applying these technologies.[16] Tractive load is a measure of the amount of force needed to move a vehicle. It not only accounts for vehicle mass, but also for tire-to-ground friction and air resistance. Technologies that reduce tractive load include mass reduction, aerodynamic drag reduction, and tire rolling resistance reduction.

Vehicle manufacturers calibrate a number of attributes, such as engine size, transmission gear ratios, axle ratio, and gear shift points, based on tractive load to optimize engine efficiency. EPA has conducted a detailed study of these factors using its ALPHA model to support the prior mid-term evaluation.[17] For any given tractive load, the gasoline engine's speed and torque must be matched to the load by appropriate selection of gear and axle ratios to maximize efficiency. Therefore, reducing tractive load without re-calibrating the powertrain causes gasoline engines to operate sub-optimally. Unless manufacturers re-adjust engine size, transmission gear ratios, axle ratio, and/or gear shift points (or some combination of these factors) when reducing tractive load, some of the benefits of load reduction are lost.

The Alliance argues that it "is not aware of any examples in which a top gear ratio was changed solely due to aerodynamic improvements" and that any "such changes would be made in response to the cumulative changes across the entire vehicle, not just aerodynamic improvements."[18] Drag reduction is usually accomplished when a vehicle body is redesigned, so gear and axle ratios are typically re-optimized for the entire set of changes, but these changes

[14] Alliance Supplemental Comment, at 17.
[15] Initial H-D Comment, at 32-33.
[16] Initial H-D Comment, at 48.
[17] Newman & Dekraker, Modeling the Effects of Transmission Gear Count, Ratio Progression, and Final Drive Ratio on Fuel Economy and Performance Using ALPHA, SAE International 2016-01-1143, April 5, 2016.
[18] Alliance Supplemental Comment, at 32.

include the drag reduction. The Alliance thus acknowledges that calibration changes are made in response to tractive load changes. In contrast, while the Agencies' Autonomie model recalibrates the powertrain in response only to large mass reduction improvements, it does not recalibrate the powertrain in response to any other vehicle changes that reduce tractive load (e.g., aerodynamic and rolling resistance improvements)—even when those changes result in a greater tractive load reduction than does a 10% mass reduction.[19] In the real world (and as captured in EPA's prior ALPHA model), automakers typically alter many vehicle attributes affecting tractive load simultaneously, including aerodynamics.

The Autonomie model simulations, the results of which are inputs to the Volpe model, do not optimize engine efficiency after most changes in tractive load because the model employs fixed shift points, gear ratios, and axle ratios when drag or tire rolling resistance is reduced. As a result, the Autonomie model outputs underrepresent the benefit of tractive load reduction strategies. EPA's prior ALPHA model does capture the adjustments automakers make when reducing tractive load, so its technology efficiency estimates better reflect reality.

*EPA Has Refuted the Alliance's Criticisms of the Lumped Parameter Model, Including Under the Current Administration.*

The Alliance argues that "technology benefit values derived from the LPM are suspect at best" because "[t]he Alliance has provided numerous reports and comments documenting its concerns with the EPA lumped parameter model."[20] "The opinion of the Alliance is that these concerns have not been adequately addressed by EPA."[21] But EPA has repeatedly responded to the Alliance's criticisms of the LPM at length, each time thoroughly disproving the criticisms of the Alliance and its consultants, Novation Analytics.

After EPA released the Draft TAR in July 2016, which evaluated the feasibility of the existing standards, the Alliance submitted comments criticizing the LPM. EPA responded to those comments in two appendices in the November 2016 TSD. Referring to Novation reports, EPA found that "[t]hese reports by the Alliance's contractor are riddled with technical flaws, unsound initial assumptions, and unsubstantiated claims that substantially skew the final conclusions. Moreover, the errors in the reports tend to systematically under-predict technology effectiveness and over-predict the cost and complexity of the technology required to meet the standards."[22] More specifically, EPA concluded that "the numerical limitations on efficiency suggested in the Novation report are not calculated in a robust and scientifically defendable way, and artificially limit potential effectiveness of powertrain components."[23]

[19] Initial H-D Comment, at 48.
[20] Alliance of Automobile Manufacturers Supplemental Comment, April 19, 2019, at 24.
[21] *Id*.
[22] Proposed Determination on the Appropriateness of the Model Year 2022-2025 Light-Duty Vehicle Greenhouse Gas Emissions Standards under the Midterm Evaluation: Technical Support Document, EPA-420-R-16-021, at A-1.
[23] *Id*.

The Alliance then submitted another comment and Novation report, but EPA again disagreed with the Alliance's arguments in the Final Determination on the Midterm Evaluation in January 2017. EPA determined that the Novation analysis was outcome-driven, finding that "the analysis conducted for the Alliance was predisposed to show a shortfall in the ability of conventional technology to meet the MY2025 standards."[24] Over a dozen pages of technical discussion, EPA demonstrated that it would be "inappropriate to replace its analysis of the future fleet of vehicles with an analysis limited by the constrained modeling concepts implemented by Novation."[25]

On September 21, 2017, after the change in administration, EPA hosted a meeting with the Alliance and Novation at which the Alliance again presented its concerns with the LPM to EPA.[26] As before, EPA addressed all of the Alliance's concerns, this time in a 37-page memo containing new data, analysis, and technical appendices. Based on the detailed technical analysis, the EPA concluded that "the findings presented by Novation on September 21st are not consistent with EPA's 2016 Proposed Determination analysis and do not support the conclusion that the LPM introduces a systemic bias into EPA's analysis."[27]

Accordingly, while the Alliance may still be dissatisfied with the LPM's technology effectiveness estimates, it cannot reasonably claim that the LPM's estimates are "suspect," or that the Alliance's concerns "have not been adequately addressed by EPA."[28] Reliance on the LPM's technology effectiveness estimates is well-supported, and they provide evidence that the Agencies improperly reduced the benefits of fuel efficiency technology in the proposed rule.

*The Agencies Erroneously Excluded Next-Generation Atkinson Technology.*

In a brief section, the Alliance reiterates statements made by Toyota in its supplemental comments regarding second-generation high compression ratio (HCR2) Atkinson technology. Specifically, the Alliance asserts that the Model Year 2018 Toyota Camry 2.5L engine is not an example of HCR2 technology, and that my estimate of HCR2 technology effectiveness is too high.

I addressed both of these points in my supplemental comments submitted on April 29, 2019.[29] Toyota's description of its advanced Atkinson technology in its 2018 Camry 2.5L engine proves that the Agencies excluded technologies from the Volpe model that improve fuel economy beyond the modeled technology combinations and are already deployed in the market.

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[24] Final Determination on the Appropriateness of the Model Year 2022-2025 Light-Duty Vehicle Greenhouse Gas Emissions Standards under the Midterm Evaluation, Response to Comments, EPA-420-R-17-002, January 19, 2017, at 31.
[25] *Id*.
[26] Stakeholder Meeting with Auto Alliance and Global Automakers and their contractor, Novation Analytics, and EPA Technical Response to Assertions of 'ALPHA-to-OMEGA Bias,' November 24, 2017, EPA-HQ-OAR-2015-0827-10988, at 1.
[27] *Id*.
[28] Alliance of Automobile Manufacturers Supplemental Comment, April 19, 2019, at 24.
[29] Supplemental H-D Comment, at 1-2.

The Alliance concedes this fact.[30] High compression ratio technologies in the 2018 Camry 2.5L engine that the Agencies excluded from the Volpe model include cooled-exhaust gas recirculation; optimized engine bore/stroke ratio, piston design, and intake/exhaust port shaping; a high energy ignition coil; an electric water pump; and a variable oil pump.[31] It is immaterial whether this collection of technologies meet an agency-invented definition of the "HCR2" technology package—the Agencies' cost of compliance modeling does not capture the 2018 Camry 2.5L engine's already-deployed improvements. The modeling thus fails to model available, cost-effective technology and overstates the cost of compliance.

The Alliance's and Toyota's argument that my estimate of advanced Atkinson technology effectiveness is too high rests on a misreading of my report. I simply used the Agencies' estimates of HCR2 technology effectiveness and verified them against data on the 2018 Camry 2.5L engine. These estimates were not too high—in fact, EPA recently tested the same engine and found that its prior estimates of HCR2 technology effectiveness were "appropriate," and "perhaps conservative."[32] If anything, this new data suggests that next-generation Atkinson technology will surpass the Agencies' expectations, especially once further improvements currently in development are introduced to the market by 2025. Therefore, the Agencies have no basis for failing to include next-generation Atkinson technology in the Volpe model.

*The Agencies Inappropriately Limited Mass Reduction's Efficacy and Increased Its Costs.*

On mass reduction costs and benefits, the Alliance's submission only demonstrates that the Agencies' treatment of mass reduction technology is erroneous. Notably, the Alliance does not contest my analysis that the Agencies wrongly decreased mass reduction efficacy by limiting glider weight[33] as a proportion of total vehicle weight. As defined by the Agencies, "mass reduction" technology reduces vehicle glider weight, rather than overall vehicle weight. Glider weight typically accounts for 70-80% of a vehicle's total weight,[34] but the Agencies unreasonably assumed glider weight to be only 50% of a vehicle's total weight. This incorrect assumption restricts mass reduction efficacy—for example, a 10% mass reduction level reduces overall vehicle mass by 5% in the Agencies' analysis (10% reduction in glider weight, which is defined as 50% of overall vehicle weight), compared to 7-8% in a correct analysis (10% of 70-80%).

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[30] Alliance Supplemental Comment, at 37 ("the 2.5L Toyota Camry engine is an example of a high compression ratio engine more advanced than the 'HCR' level described by the Agencies in the PRIA").

[31] *See* Supplemental H-D Comment, at 1.

[32] Kargul, et al., Benchmarking a 2018 Toyota Camry 2.5-Liter Atkinson Cycle Engine with Cooled-EGR, SAE International, April 2, 2019, at 18; Supplemental H-D Comment, at 2.

[33] A vehicle glider is an entire vehicle minus the powertrain.

[34] K. Gopal Duleep, Review of the Technology Costs and Effectiveness Utilized in the Proposed SAFE Rule, October 2018, at 43, 49-50.

Instead, the Alliance replies to a brief statement in my comment where I observe that the model fails to account for powertrain mass reductions at lower mass reduction levels.[35] Powertrain mass reduction commonly occurs when manufacturers reduce engine cylinder count or replace heavy engine components with lightweight ones, such as composite intake manifolds. The Alliance asserts that powertrain downsizing tends to occur with powertrain redesigns and only after manufacturers substantially reduce glider mass, and that it is appropriate to limit powertrain resizing to instances where mass is reduced by 10% or more.[36] But the Alliance concedes that manufacturers do downsize powertrains, and that "powertrain downsizing can have the greatest secondary mass reduction benefit."[37] The Alliance's comments thus confirm that powertrain mass reduction is a viable option for manufacturers to comply with emissions and fuel economy standards. The only rationale offered for limiting resizing to the higher levels of mass reduction (e.g., long life-cycles of powertrains and sharing of powertrains across platforms) concerns manufacturers' choices whether to resize powertrains, not whether such resizing is feasible or would further improve fuel economy. Nothing in the Alliance's supplemental comment justifies the Agencies' decision not to model powertrain resizing at lower levels of mass reduction, especially when combined with aerodynamic drag reduction and reduced rolling resistance.

The Alliance's supplemental comment also mentions assignment of baseline mass reduction levels, but it once again does not address my primary criticism. In my initial comment, I explained that the regression the Agencies used to assign baseline mass reduction levels is flawed, likely due to collinearity between the independent variables in the regression employed.[38] As examples, I noted that the baseline mass reduction levels assigned to the 2016 Mazda MX-5 and 2016 Chevrolet Malibu were too high.[39] In response, the Alliance does not defend the Agencies' regression, nor does the Alliance address my observations of abnormal coefficients and collinearity. Rather, the Alliance states that the 2016 Mazda MX-5 and 2016 Chevrolet Malibu are among the lightest cars of similar design and size, apparently to refute my examples.[40] However, even though the MX-5 and Malibu are lighter than most similar cars, the Agencies nonetheless assigned them far too high of a baseline mass reduction attribute. The base Malibu—to which the Agencies assigned a mass reduction level of MR5—has a test weight of 3,375 pounds, while the 2016 Honda Accord—to which the Agencies assigned the lowest mass reduction level of MR0—has a test weight of 3,500 pounds.[41] The weight difference between the Malibu and Accord is 3.57%, far smaller than the 10% weight reduction produced by MR5 over MR0 at 50% glider weight. Similarly, the MX-5 was wrongly assigned the highest mass

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[35] Initial H-D Comment at 50.
[36] Alliance Supplemental Comment, at 35-36.
[37] Alliance of Automobile Manufacturers Supplemental Comment, April 19, 2019, at 35 (quoting National Research Council, Cost, Effectiveness and Deployment of Fuel Economy Technologies for Light-Duty Vehicles, 2015, at 220-21).
[38] Initial H-D Comment, at 50. Collinearity exists when independent variables are highly correlated with one another.
[39] *Id*.
[40] Alliance Supplemental Comment, at 36.
[41] EPA 2016 Test Car List Data, *available at* https://www.epa.gov/sites/production/files/2016-07/16tstcar.csv; October 2018 PRIA at Table 6-58.

reduction level (level MR5).[42] MR5 is reserved for top upgrades such as an all-aluminum body,[43] but the MX-5 lacks those attributes.[44] In reality, Mazda could improve the MX-5's fuel efficiency by giving it, for example, an all-aluminum body, but the model assumes no further mass reduction upgrades are possible.

On mass reduction costs, the Alliance's comments contain errors and expose more problems with the Agencies' analysis. The Alliance criticizes the PRIA as unreliable, and suggests that any study of mass reduction costs must instead examine the Volpe model files.[45] But the PRIA tables must reflect the mass reduction costs in the Volpe model files—to the extent that they disagree, as the Alliance suggests,[46] that only further demonstrates that the Agencies' own documentation is flawed and misleading. Contrary to the Alliance's suggestion that the Agencies may "further explain the derivation and application of mass reduction costs to whatever extent is deemed necessary,"[47] the Agencies should release a comprehensive, transparent accounting of mass reduction costs and subsequently allow public comment.

In addition, the Alliance's comments do not explain that the Agencies' 2016 analysis included two estimates of mass reduction costs: one from EPA, and one from NHTSA. As demonstrated in my initial comments, the Agencies' estimate of mass reduction costs in the 2018 PRIA are far higher than EPA's reliable calculation of mass reduction costs in 2016.[48] EPA should acknowledge and justify its departure from its previous estimate.

The Alliance does not dispute the conclusion that EPA's cost estimates are much higher in the 2018 PRIA. Instead, it incorrectly asserts that the Agencies' estimate of mass reduction costs in the 2018 PRIA is substantially lower than NHTSA's 2016 estimate.[49] The Alliance committed a basic error that led it to draw this incorrect conclusion. Specifically, the Alliance misinterpreted data in the NPRM Volpe input file as presenting incremental costs of mass reduction over the next-lower mass reduction level, when in fact those data refer to average total costs relative to mass reduction level zero.[50] This error massively influences the Alliance's calculation of mass reduction costs—for example, when calculating the cost of MR5 in Table C-

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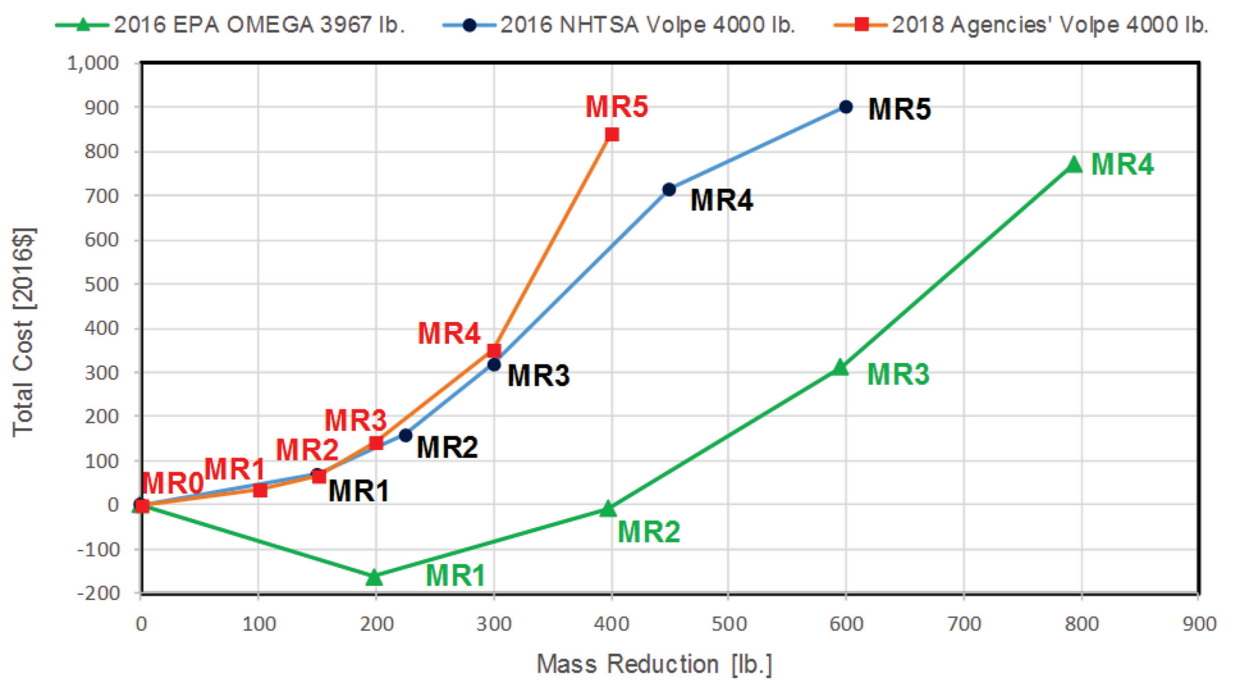
[42] October 2018 PRIA at Table 6-58.
[43] October 2018 PRIA, at 402.
[44] 2019 Mazda MX-5 Press Kit, available at https://1ijylmozio83m2nkr2v293mp-wpengine.netdna-ssl.com/wp-content/uploads/2018/07/2019-Mazda-MX-5-Press-Kit_Version-2.pdf, at 2, 15.
[45] Alliance Supplemental Comment, at 45.
[46] Alliance Supplemental Comment, at 45.
[47] *Id*.
[48] K. Gopal Duleep, Review of the Technology Costs and Effectiveness Utilized in the Proposed SAFE Rule, October 2018, at 20 Table 3.5 (referring to 2016 TSD).
[49] Alliance Supplemental Comment, at 45.
[50] The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Year 2021 – 2026 Passenger Cars and Light Trucks, Preliminary Regulatory Impact Analysis, October 16, 2018, at 391 ("Previously, in the Draft TAR, the agencies provided an incremental cost per pound for each stage of mass reduction. For today's analysis, the agencies present an average cost per pound over the baseline (MR0) for the vehicle's glider weight.").

12 of its supplemental comment, the Alliance assumed that the first 100 lbs. of mass reduction would cost $0.37/lb., the next 50 lbs. of mass reduction would cost $0.45/lb., the next 50 lbs. of mass reduction would cost $0.71/lb., the next 100 lbs. of mass reduction would cost $1.17/lb., and that only the final 100 lbs. of mass reduction would cost $2.11/lb. From that assumption, the Alliance calculated that MR5 would cost $422.37. However, because the Alliance's source data presents total costs relative to mass reduction level zero, and not incremental costs relative to the prior mass reduction level as the Alliance assumed, the entire 400 lbs. of mass reduction costs $2.11/lb. When the Alliance's mistake is corrected, the actual cost used by the Agencies is $843.23, double what the Alliance reported.[51]

As shown in Table 1 below, the mass reduction costs used in the 2018 rulemaking are much higher than the Alliance reports. Furthermore, Figure 1 below shows that the costs NHTSA used in 2016 are also greater at higher levels of mass reduction.

Figure 1: Comparison of Draft TAR and NPRM/PRIA Total Mass Reduction Costs




[51] The Alliance also erred in assuming glider weight to be 66.7% of total vehicle weight in the NHTSA 2016 cost estimate. The Alliance explains that it obtained this value from personal communication with the Volpe Center, Alliance Supplemental Comment at 64 (Table C-11), but the 2018 PRIA states on page 418 that the 2016 analysis assumed glider weight to be 75% of total weight. Correcting this error decreases mass reduction costs per pound in the NHTSA 2016 analysis, but the Agencies' estimate of mass reduction costs in the 2018 PRIA remains higher even if a glider weight proportion of 66.7% is used.

Table 1: Mass Reduction Costs for a 4000 lb. Medium Car in 2021 for the Agencies' Volpe Model in the 2018 NPRM/PRIA, as Computed by the Alliance and Corrected by H-D Systems

| Technology Level | Cost (Alliance) | Cost (H-D Systems) |
|---|---|---|
| **MR1** | $36.95 | $36.95 |
| **MR2** | $59.50 | $67.67 |
| **MR3** | $94.91 | $141.53 |
| **MR4** | $211.56 | $349.96 |
| **MR5** | $422.37 | $843.23 |

Sources: Alliance of Automobile Manufacturers Supplemental Comment, April 19, 2019, at 65 Table C-12 (Alliance numbers); Appendix A, Table A-2 (H-D Systems numbers)

*Discrepancies in Electrification Technology Cost Estimates Derived from the October PRIA Originate from Irreconcilable Data in the PRIA.*

The Alliance makes two assertions regarding electrification costs. First, the Alliance argues that I focused my analysis on the increase in costs between EPA's estimates in its 2016 TSD and the Agencies' estimates in the 2018 NPRM, rather than NHTSA's estimates in the 2016 Draft TAR.[52] As an initial matter, belt-integrated starter generator (BISG) costs shown in Tables 6-30 and 6-31 of the PRIA are much greater than NHTSA's cost estimate in the 2016 Draft TAR, as calculated by the Alliance.[53] Moreover, the dramatic increase in EPA's estimate of electrification costs from 2016 to 2018 is important. The Alliance acknowledges this when it asks EPA to explain its departure from the previous estimates.[54]

Table 2 (below) demonstrates the substantial increase in EPA's estimates of electrification technology costs between the 2016 proposed determination and the 2018 rulemaking. Table 2 shows the costs of various electrification technologies over the base vehicle in model year 2017 and model year 2025, as determined in the 2016 TSD and 2018 PRIA. Two different calculation methods were used to present costs in the October 2018 PRIA: one using the methodology in my initial comment (based on Tables 6-30 and 6-31), and one similar to the Alliance's methodology (based on Tables 6-32 and 6-33). The inconsistencies between tables in the October 2018 PRIA are discussed in more detail below. My methodology for calculating electrification costs based on Tables 6-30 and 6-31 is in Appendix B.[55]

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[52] Alliance Supplemental Comment, at 40-41.

[53] Compare H-D Systems' values in Table A-2 (see Appendix A), with Alliance Supplemental Comment at 41 (Table 10). The Alliance does not tabulate NHTSA's cost estimate in the 2016 Draft TAR for any other electrification technologies.

[54] Alliance Supplemental Comment, at 40 (encouraging "the Agencies to explain why one projection was used over the other in cases where there is significant variation between the two.").

[55] My October 2018 PRIA cost estimates in Table 2 are adjusted from those in my initial comment to correct an inadvertent mistake in the learning curve figures used in the calculation.

Table 2: Comparison of Electrification Technology Direct Manufacturing Costs over the Base Vehicle between the 2016 TSD and October 2018 PRIA

| Technology | Year | 2016 TSD[56] | October 2018 PRIA (Tables 6-30 & 6-31) | October 2018 PRIA (Tables 6-32 & 6-33)[57] |
|---|---|---|---|---|
| SS12V | MY 2017 | $268 - $333 | $326 - $403 | $439 - $490 |
| | MY 2025 | $205 - $254 | $246 - $304 | $339 - $379 |
| BISG[58] | MY 2017 | $724 | $1,499 - $1,733 | $1,097 - $1,506 |
| | MY 2025 | $580 | $981 - $1,124 | $740 - $997 |
| SHEV(P2) | MY 2017 | $2,602 - $3,290 | $4,258 - $5,915 | $2,959 - $3,236 |
| | MY 2025 | $2,124 - $2,697 | $3,145 - $4,283 | $2,177 - $2,368 |
| SHEV(PS)[59] | MY 2017 | $2,602 - $3,290 | $6,299 - $8,354 | $5,807 - $7,221 |
| | MY 2025 | $2,124 - $2,697 | $4,708 - $6,264 | $4,380 - $5,446 |

Source of 2016 TSD figures: 2016 TSD at Tables 2.89, 2.94, 2.95

As shown in Table 2, the Agencies essentially doubled the cost of BISG and SHEV(PS) technology in the PRIA (under either methodology) compared to EPA's values in the 2016 TSD. The Agencies also substantially increased the cost of SS12V (under either methodology) and SHEV(P2) (under my methodology). This change substantially increased EPA's estimates of automobile manufacturers' costs to comply with the existing standards by assuming hybrid and electric vehicles cost more to make. Furthermore, the Agencies posited in the PRIA that manufacturers will require much more electrification to comply with the existing standards than EPA previously determined.[60] The increased electrification costs are thus more consequential than in the Agencies' prior analysis.

Second, the Alliance asserts that discrepancies between our tabulations of electrification technologies' costs in the PRIA render my analysis unreliable.[61] However, as I explain below, the so-called discrepancies in electrification technology costs stem from inconsistencies in the Agencies' PRIA tables. My conclusion that the Agencies erroneously increased their estimates of electrification technology costs in the 2018 PRIA remains valid.

[56] Note that the 2016 presents costs in 2015 dollars, whereas the October 2018 PRIA presents costs in 2016 dollars. The costs in Table 2 are not adjusted for inflation, but such an adjustment would have little effect on the figures.
[57] Tables 6-32 and 6-33 present retail costs, not direct manufacturing costs, so direct manufacturing cost estimates in this column were derived from retail costs. The Alliance performed this adjustment in its tabulation.
[58] Inexplicably, the minimum BISG costs based on Tables 6-32 and 6-33 in the October 2018 PRIA are cost estimates for larger vehicles.
[59] The model was constrained to prevent power split technology from being applied to pickup trucks, so the maximum cost estimates are those for the medium performance SUV.
[60] October 2018 PRIA at 554 Table 7-6.
[61] Alliance Supplemental Comment, at 38.

The Alliance criticizes my tabulation of electrification costs in the NPRM because it differs substantially from the Alliance's calculations.[62] I present a comparison of electrification costs in the PRIA as reported by the Alliance and myself in Table 3 below. This comparison reveals substantial discrepancies in strong hybrid technology (SHEV(P2) and SHEV(PS)) cost estimates. As an initial matter, the fact that the Alliance and I can come to such different conclusions about what should be a basic factual matter—the cost of electrification technologies used by the Agencies in its modeling—demonstrates the rulemaking's opacity. It is difficult to comment on the Agencies' analysis when the Agencies have made it unclear what fundamental assumptions the Agencies made in the first place.

Table 3: Comparison of Electrification Technology Direct Manufacturing Costs over the Base Vehicle in the October 2018 PRIA as Reported by the Alliance and as Determined by H-D Systems

| Technology | Year | October 2018 PRIA (Alliance) | October 2018 PRIA (H-D Systems) |
|---|---|---|---|
| SS12V | MY 2017 | Not reported | $326 - $370 |
| | MY 2025 | Not reported | $246 - $279 |
| BISG | MY 2017 | $1,079 - $1,483 | $1,499 - $1,695 |
| | MY 2025 | $728 - $982 | $981 - $1,101 |
| SHEV(P2) | MY 2017 | $2,915 - $3,191 | $4,258 - $5,767 |
| | MY 2025 | $2,144 - $2,351 | $3,145 - $4,283 |
| SHEV(PS) | MY 2017 | $5,731 - $7,127 | $6,299 - $8,354 |
| | MY 2025 | $4,324 - $5,377 | $4,708- $6,264 |

The Alliance implies that the differences may be caused by my reference to the July 2018 PRIA instead of the updated October 2018 PRIA,[63] but that is incorrect. The corrections and updates in the October 2018 PRIA actually increased technology costs, only widening the discrepancies between the Alliance's and my tabulation of electrification costs in the October 2018 PRIA.[64] In fact, the discrepancies identified by the Alliance are due to internal inconsistencies in the PRIA that are present in both versions.

The October 2018 PRIA provides the direct manufacturing costs for electrification technologies in Tables 6-30 and 6-31.[65] For each technology, these tables present direct manufacturing costs as incremental to prerequisite electrification technologies. The simplest way to determine electrification costs for each technology is to add a technology's incremental cost to the cumulative incremental costs of all prerequisite technologies, and to then adjust those

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[62] Alliance Supplemental Comment, at 43.
[63] Alliance Supplemental Comment, at 40.
[64] Compare July 2018 PRIA, Table 6-29, with October 2018 PRIA, Table 6-29.
[65] The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Year 2021 – 2026 Passenger Cars and Light Trucks, Preliminary Regulatory Impact Analysis, October 16, 2018, at 378-79 Tables 6-30 and 6-31.

costs for manufacturer learning factors[66] to arrive at model year 2017 and model year 2025 cost estimates. I used this methodology.

The Alliance used a different, less direct methodology. Rather than calculating direct manufacturing costs using PRIA data on direct manufacturing costs, the Alliance began with non-battery *retail* costs. It then converted those non-battery retail costs to non-battery direct manufacturing costs using the Agencies' retail price equivalents value.[67] The Alliance next added its calculated non-battery direct manufacturing costs to battery direct manufacturing costs, which it calculated by adjusting direct manufacturing costs in the PRIA according to the Agencies' leaning factor.[68] Finally, the Alliance adjusted its result for inflation, although this adjustment has only a small effect.[69,70,71]

Not only does the Alliance's unnecessarily complex methodology demonstrate the absurdity of requiring the public to implement complicated calculations to discern values for the Agencies' basic inputs, it also reveals inconsistencies between tables in the PRIA. For example, Tables 6-30 and 6-31 of the PRIA present total direct manufacturing costs for SHEV(P2) technology of $5,647.23 to $7,714.78.[72] This total should be substantially less than the sum of *retail* battery costs for SHEV(P2) technology (derived from Table 6-29) and *retail* non-battery costs for SHEV(P2) (provided in Tables 6-32 and 6-33). But that math returns SHEV(P2) total costs of $4,113.18 to $4,516.07—a fraction of the costs shown in Tables 6-30 and 6-31.[73] While the fully adjusted figures in Table 2 above rigorously document the discrepancies in electrification costs produced by irreconcilable data in PRIA tables, this back-of-the-envelope comparison highlights that the figures in these PRIA tables are the source of the problem. The gaps between the numbers in the PRIA tables mirror the divergences between my estimates and the Alliance's cost estimates. These internal inconsistencies in the PRIA—and not any alleged error on my part—are thus the proper target of the Alliance's criticism.

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[66] See October 2018 PRIA, at Table 6-34, Figure 6-154.

[67] Alliance Supplemental Comment, at 57-58 (Tables C-1 and C-2).

[68] *Id*.

[69] *Id*.

[70] Note that the Alliance overestimates the range of values because its methodology pairs the lowest non-battery cost with the lowest battery cost and the highest non-battery cost with the highest battery cost, when in fact those values are not paired in the model. October 2018 PRIA Tables 6-29, 6-32, and 6-33; CAFE Model file '2018_NPRM_technologies_with_BEV_and_FCV_ref.xlsx'.

[71] The Alliance also argues that my calculations are flawed because they do not account for inflation, but adjusting for inflation over three years (2013 to 2016) would only minimally change the cost estimates and invite debate over the proper inflation index to use.

[72] These figures were calculated by adding the cost of SHEV(P2) to the cost of electrification technologies to which Tables 6-30 and 6-31 state SHEV(P2) is incremental.

[73] These figures were calculated by multiplying the battery direct manufacturing cost in Table 6-29 by 1.5 to adjust to retail cost, and adding the non-battery cost of SHEV(P2) in Tables 6-32 and 6-33. Note that this methodology significantly overestimates direct manufacturing costs of SHEV(P2) technology because it uses retail costs rather than direct manufacturing costs.

*Conclusions*

As noted above, the Alliance submitted its supplemental comment long after the close of the public comment period, leaving me without adequate time to thoroughly rebut all of the Alliance's contentions. Nevertheless, as demonstrated above, the Alliance's supplemental comments do not undermine the conclusions in my initial comments. The Agencies exaggerated the cost of meeting the existing standards in the 2018 SAFE proposal by inappropriately constraining technology paths, increasing technology cost estimates, and reducing technology effectiveness estimates. The Agencies' 2016 findings supporting the existing standards remain appropriate.

Sincerely,

G. Duleep

Appendix A: Tabulation of Electrification Costs in the October 2018 PRIA

Table A-1: Mass Reduction Costs for a 4000 lb. Medium Car in 2021 for the NHTSA Volpe Model in the 2016 Draft TAR[74]

| | | | MR0 | MR1 | MR2 | MR3 | MR4 | MR5 |
|---|---|---|---|---|---|---|---|---|
| A | **Total Mass Reduction** | [% Glider Weight] | 0 | 5 | 7.5 | 10 | 15 | 20 |
| B | **Incremental Mass Reduction** | [% Glider Weight] | 0 | 5 | 2.5 | 2.5 | 5 | 5 |
| C | **Glider Portion of Vehicle** | [%] | 75 | 75 | 75 | 75 | 75 | 75 |
| D | **Total Mass Reduction** | [lb] | 0 | 150 | 225 | 300 | 450 | 600 |
| E | **Incremental Mass Reduction** | [lb] | 0 | 150 | 75 | 75 | 150 | 150 |
| F | **Incremental Cost per Pound** | [2013$/lb] | 0.00 | 0.45 | 1.13 | 2.07 | 2.54 | 1.19 |
| G | **2013$ to 2016$ Conversion** | [-] | 1.041 | 1.041 | 1.041 | 1.041 | 1.041 | 1.041 |
| H | **Incremental Cost per Pound** | [2016$/lb] | 0.00 | 0.47 | 1.17 | 2.16 | 2.64 | 1.24 |
| I | **Incremental Cost** | [2016$] | 0 | 70.26 | 87.85 | 161.85 | 396.75 | 186.21 |
| J | **Total Cost** | [2016$] | 0 | 70.26 | 158.11 | 319.97 | 716.72 | 902.93 |

Sources: Draft TAR Central Analysis Volpe Input File for 2021 MedCar; October 2018 PRIA, at 418; United States Bureau of Economic Analysis (bea.gov, accessed on May 3, 2019)[75]

Table A-2: Mass Reduction Costs for a 4000 lb. Medium Car in 2021 for the Volpe Model in the 2018 NPRM/PRIA

| | | | MR0 | MR1 | MR2 | MR3 | MR4 | MR5 |
|---|---|---|---|---|---|---|---|---|
| A | **Total Mass Reduction** | [% Glider Weight] | 0 | 5 | 7.5 | 10 | 15 | 20 |
| B | **Glider Portion of Vehicle** | [%] | 50 | 50 | 50 | 50 | 50 | 50 |
| C | **Total Mass Reduction** | [lb] | 0 | 100 | 150 | 200 | 300 | 400 |
| D | **Cost per Pound Relative to MR0** | [2016$/lb] | 0.00 | 0.37 | 0.45 | 0.71 | 1.17 | 2.11 |
| E | **Total Cost** | [2016$] | 0.00 | 36.95 | 67.67 | 141.65 | 349.96 | 843.23 |

Sources: NPRM Central Analysis Volpe Input File for 2021 MedCar; October 2018 PRIA, at 418[76]

[74] Note that mass reduction costs in Tables A-1 and A-2 are not comparable between the same mass reduction levels because the same mass reduction levels represent different amounts of total mass reduction. For example, MR5 in the 2016 Draft TAR (Table A-1) represents 600 lbs. of mass reduction, whereas MR5 in the 2018 NPRM/PRIA (Table A-2) represents 400 lbs. of mass reduction. This incomparability stems from the Agencies' decision to reduce the glider portion of vehicle mass from 75% to 50% in the 2018 NPRM/PRIA.

[75] Row A calculated from B; Row B and Row F obtained from Draft TAR Central Analysis Volpe Input File for 2021 MedCar; Row C obtained from October 2018 PRIA, at 418; Row D calculated from Row A and Row C for 4000 lb. vehicle; Row E calculated from Row B and Row C for 4000 lb. vehicle; Row G sourced from the United States Bureau of Economic Analysis (bea.gov, accessed on May 3, 2019); Row H calculated from Row F and Row G; Row I calculated from Row E and Row H; Row J calculated from Row I.

[76] Row A and Row D obtained from NPRM Central Analysis Volpe Input File for 2021 MedCar; Row B obtained from October 2018 PRIA, at 418; Row C calculated from Row A and Row B for a 4000 lb. vehicle; Row E calculated from Row C and Row D.

Table A-3: Mass Reduction Costs for a Class 6 Car (3967 lb.) in 2021 for the EPA OMEGA Model in the 2016 Draft TAR

| | | | MR0 | MR1 | MR2 | MR3 | MR4 |
|---|---|---|---|---|---|---|---|
| **A** | **Total Mass Reduction** | [% Glider Weight] | 0 | 5 | 10 | 15 | 20 |
| **B** | **Curb Weight** | [lb] | 3967 | 3967 | 3967 | 3967 | 3967 |
| **C** | **Total Mass Reduction** | [lb] | 0 | 198 | 397 | 595 | 793 |
| **D** | **Total Cost** | [2013$/lb] | 0 | -163.00 | -9.00 | 313.00 | 772.00 |
| **E** | **2013$ to 2016$ Conversion** | [-] | 1.041 | 1.041 | 1.041 | 1.041 | 1.041 |
| **F** | **Total Cost** | [2016$/lb] | 0.00 | -169.70 | -9.37 | 325.86 | 803.71 |

Sources: Draft TAR, at 5-404 to 5-407 Tables 5.157-160; United States Bureau of Economic Analysis (bea.gov, accessed on May 3, 2019)[77]

[77] Row A, Row B, and Row D obtained from curb weights and total costs of a 2021 vehicle as shown in Table 5.157 through 5.160 on pages 5-404 to 5-407 of 2016 Draft TAR; Row C calculated from Row A and Row B; Row E sourced from United States Bureau of Economic Analysis (bea.gov, accessed on May 3, 2019); Row F calculated from Row D and Row E.

Appendix B: Tabulation of Electrification Costs in the October 2018 PRIA, Based on Tables 6-30 and 6-31

Table B-1: Incremental Electrification Costs from Tables 6-30 and 6-31

| Incremental Cost From Tables 6-30 and 6-31 | | | | | |
|---|---|---|---|---|---|
| Tech | Small Car | | MedSUV | | |
| | Incremental Cost | Absolute Cost | Incremental Cost | Absolute Cost | Incremental To |
| EPS | 93.59 | 93.59 | 93.59 | 93.59 | BaseV |
| IACC | 49.55 | 143.14 | 49.55 | 143.14 | EPS |
| SS12V | 259.51 | 402.65 | 313.55 | 456.69 | IACC |
| BISG | 1055.94 | 1458.59 | 1212.01 | 1668.70 | SS12V |
| CISG | 2210.82 | 2613.47 | 3432.94 | 3889.63 | SS12V |
| SHEVP2 | 1977.82 | 4591.29 | 2437.05 | 6326.68 | CISG |
| SHEVPS | 1875.25 | 6466.54 | 2310.66 | 8637.34 | SHEVP2 |

Table B-2: Base Battery Costs for Small Cars and Medium SUVs from Table 6-29

| Table 6-29 | | |
|---|---|---|
| Tech | Base Battery Costs | |
| | Small Car | MedSUV |
| EPS | 0 | 0 |
| IACC | 0 | 0 |
| SS12V | 0 | 0 |
| BISG | 650 | 650 |
| CISG | 847 | 847 |
| SHEVP2 | 1294 | 1459 |
| SHEVPS | 1294 | 1459 |

Table B-3: Electrification Costs Based on Tables 6-29 to 6-31 in the October 2018 PRIA

| Tech | CY2017 | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Learning | | Battery Cost | | Non-Battery Cost | | Total DMC | |
| | Battery | Non-Battery | Small Car | MedSUV | Small Car | MedSUV | Small Car | MedSUV |
| EPS | - | 0.91 | - | - | 85.17 | 85.17 | 85.17 | 85.17 |
| IACC | - | 0.88 | - | - | 125.57 | 125.57 | 125.57 | 125.57 |
| SS12V | - | 0.81 | - | - | 326.15 | 369.92 | 326.15 | 369.92 |
| BISG | 1.15 | 0.93 | 747.50 | 747.50 | 751.99 | 947.39 | 1499.49 | 1694.89 |
| CISG | 1.15 | 0.93 | 974.05 | 974.05 | 1642.82 | 2829.65 | 2616.87 | 3803.70 |
| SHEVP2 | 1.15 | 0.84 | 1488.10 | 1677.85 | 2769.72 | 4088.85 | 4257.82 | 5766.70 |
| SHEVPS | 1.15 | 0.93 | 1488.10 | 1677.85 | 4810.46 | 6675.86 | 6298.56 | 8353.71 |