International Council on Clean Transportation comments on the Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021-2026 Passenger Cars and Light Trucks

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PUBLIC COMMENTS SUMMARY

The International Council on Clean Transportation (ICCT) provides these comments to *The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021-2026 Passenger Cars and Light Trucks*, which proposes to revise the model year 2021–2026 light-duty vehicle greenhouse gas (GHG) emissions and corporate average fuel economy (CAFE) standards.

This "public comments summary" discusses the major categories of deficiencies in the agencies' analysis of technology inputs, modelling, and, ultimately, compliance cost projections. Our complete detailed discussion, with the supporting documentation and references for all content discussed in this summary, is available in the Appendix attached hereto.

These comments demonstrate that the technology, cost, and benefit inputs and methodologies used by the agencies are deeply flawed and directly contrary to accepted scientific practices. The agencies have made unwarranted modifications to the previously-used and rigorously-supported technology inputs in the joint-agency (i.e., Environmental Protection Agency, National Highway Traffic Safety Administration, California Air Resource Board) Draft Technical Assessment Report from 2016 and Environmental Protection Agency's 2016 Proposed Determination and 2017 Final Determination, and the associated supporting documentation.

The agencies have failed to include recent technology developments and also failed to provide reasonable explanations for their deviations from their previous assessments. The deviations made in analytical methods and the novel benefit-cost approach are error-filled and incompatible with real-world technology impacts from regulatory standards. Further, the novel regulatory analytical approach is out of line with any such vehicle regulation analysis, much less best practices, that we have seen in our two decades of work assessing vehicle technologies and policies in the United States and throughout the world.

The agencies have, with their series of novel and largely unsupported new decisions, artificially inflated modeled compliance costs, while removing known real-world benefits. The overall result of the agencies' decisions is to erroneously flip the regulatory 2021-2025 standards from being a societal benefit-cost winner (with 2-3 times greater benefit than cost for the current standards) to appear to be the opposite. This artificial flip is used to rationalize freezing the standards in a de facto de-regulation of vehicle GHG emission and fuel economy regulations from 2021 on, in proposed standards that are neither "appropriate" by EPA terms nor "maximum feasible" by NHTSA terms.

Below we summarize our comments on the proposed rule in the areas of technology effectiveness, technology availability, technology pathways, modeling approach, technology cost, baseline technology, fleet rebound and safety, consumer value, regulatory certainty, international competitiveness, and zero-emission vehicles. We note that full substantiation of each point with the applicable references is provided in the Appendix that is attached.

Technology effectiveness and availability

The agencies have dramatically restricted the available technology improvements in their modeling of industry compliance with the Augural 2025 standards and other scenarios. The agencies artificially limit both the effectiveness and the availability of technologies that increase vehicle efficiency and reduce GHG emissions.

High-compression ratio (HCR) engine technology – in use today by at least six automakers – appears to be representative of the agencies' invalid and biased decisions to disregard auto industry developments and remove highly cost-effective technology from use to meet future-year standards. The agencies constrain HCR technology by disallowing it from 70% of the new vehicle fleet (i.e., for all vehicle models for companies that do not currently deploy it on their non-hybrid vehicles). By the agencies' own analysis, HCR of levels 1 (HCR1) and 2 (HCR2), is highly cost-effective. The first clear evidence of this unreasonable constraint is that, when the agencies allow automakers to fully adopt the technology, a near complete shift to the technology occurs in the agencies' model by 2025. Second, when the agencies remove their arbitrarily-set HCR constraints for other automakers in their CAFE model, the fleet complies with the standards with an average fleet savings of approximately $600 per vehicle in 2025 – approximately a 30% decrease in overall fleetwide compliance costs. A technology approach this cost-effective, and in use by Mazda and Toyota on non-hybrids (and also by Ford, General Motors, Hyundai, and Nissan, for example, on hybrids) is likely to be adopted more broadly by automakers - and is available to virtually all of them. By disallowing the automakers from adopt the most cost-effective technologies, the agencies are falsely increasing the modeled compliance costs and proving that their overall fleet compliance modeling effort is invalid.

For the agencies to constrain HCR technology for use by other automakers, they have a responsibility to demonstrate why each of the other automakers cannot adopt this known technology in their fleet. The agencies, with their manufacturer-specific constraints, show they have not consulted the recent data record, including real-world technology deployment and existing agency data from EPA, to develop a realistic CAFE fleet compliance model. The agencies' decision to set company paths based on their 2016 baseline fleet belies the historical record for technology adoption. The manufacturer-constraining logic of the agencies is shown to be faulty by the recent Toyota example: In the 2016 TAR, based on 2015 data, NHTSA had decided Toyota was disallowed from deploying HCR through 2025. Just one year later, Toyota deployed HCR in its model year 2016 vehicles, proving NHTSA's modeling of Toyota to be wrong for model years 2017 through 2025. The agencies choice to neglect, ignore, or conduct adequate research on technology developments like this HCR trend discredits the agencies' efforts to project fleet technology penetration. Also, examining the recent historical record, we find over 50 examples of companies applying efficiency technologies by 2016 that they had not utilized 8 years previously (on the analysis fleet used for the 2012 rule), debunking the agencies' insistence in the CAFE model that it is somehow reasonable to limit future year technologies based on currently-adopted technologies by each manufacturer (see Sections I.A.1 and I.B.2 below).

Beyond HCR engine technology, the agencies invalidly dismissed or removed many technologies that are viable and being actively deployed by the auto industry. The agencies have not justified why each company cannot deploy each of these technologies, and, in fact, many companies are proving that the agencies have made false and unsupportable assumptions with their technology constraints. Ongoing developments by Mazda assure that next-level HCR technology will be deployed. A model is already available in Europe, EPA has the benchmarked data and a corresponding engine map, and EPA has data on an advanced version with cooled exhaust gas recirculation and high energy ignition that the agencies have artificially excluded (see Section I.A.5). Similarly, the agencies acknowledge that homogeneous charge compression ignition (HCCI) for gasoline engines is in Mazda's production plans for 2019 (called Spark Controlled Compression Ignition, or SpCCI), yet they choose to dismiss the technology for deployment by all companies (including Mazda) through 2025 and beyond (see I.A.4). Other examples include artificial and unexplained restrictions on electric turbocharging or

"e-boost" which is in use by Volkswagen and Mercedes (see I.A.6), turbocharged HCR "Miller cycle" engines being used by Volkswagen and Mazda (see I.A.5), and variable compression ratio technology in use by Nissan (see I.B.2) which have each also been disallowed for all companies through model year 2025.

At a minimum, if the agencies are going to argue that the fleet cannot adopt these technologies, they will need to systematically investigate what the automakers are already doing and what they have announced they will do within several years. From the examples we found, it is apparent the agencies have not done this basic due diligence and have likewise disregarded essentially all of the prior administrative record projecting use of these technologies, all without explanation. If the agencies are going to adopt these technology constraints, they are responsible for arguing if, how, and why these constraints exist on a company-by-company basis. This means specifically demonstrating why each of BMW, Daimler, FCA, Ford, GM, Honda, Hyundai, Kia, JLR, Mazda, Nissan, Subaru, Volvo, and VW is incapable of deploying the technology. It is utterly inconceivable that all these companies cannot deploy each of these technologies—HCR2, cooled exhaust gas recirculation (CEGR2), Miller Cycle, variable compression ratio (VCR), HCCI, e-boost—which the agencies have decided inappropriately to constrain from use by all companies through 2025. This makes it clear that the agencies did not consult with the automakers on all these applicable but disallowed technologies. Because it is clear that there is going to be deployment of these advanced technologies in the 2025 timeframe, it is apparent that one of the parties (automakers in providing info to the agencies, or the agencies in sharing reasons for their industry-wide constraints) is being less than straightforward.

For the agencies to disallow technologies that were analyzed in the previous TAR and original 2017 Final Determinations, that are being applied by automakers, and that are benchmarked and readily analyzable by EPA's experts is highly problematic and unreasonable. This demonstrates an evident bias to remove technology that ultimately artificially makes the Augural 2025 CAFE and adopted 2025 GHG standards appear to have higher modeled compliance costs in the proposed cost-benefit analysis. If the agencies do not allow all the above-mentioned efficiency technologies in their future-year fleet modeling, such that they can be deployed if and when cost-effective compared to other technologies, the agencies' modeling effort in the CAFE modeling system will remain invalid.

Separate from the question of limiting the availability of technologies, the agencies also made a series of assumption changes that greatly reduce the availability of given technologies. The agencies have greatly limited the availability of many load reduction technologies by pushing very large amounts of these technologies into the 2016 model year baseline fleet, thereby making the technologies unavailable for use in future years. These changes were dramatic. The agencies completely changed their assumed technology adoption in the model year 2016 baseline in the NPRM (compared to the for 2015 baseline in the draft TAR and original Proposed Determination) to have over 7.6 million vehicles with mass-reduction technology packages, 3.2 million vehicles with aerodynamic packages, 7 million vehicles with low rolling resistance packages, 14.5 million vehicles with electric power steering, and 3.7 million vehicles with improved accessory packages (out of more than 16 million total sales). These would ostensibly amount to massive efficiency improvements; however, these assumed changes have not been substantiated as resulting in any test-cycle efficiency improvements in the model year 2016 fleet versus the 2015 fleet. The adjusted baseline has been developed and presented opaquely, apparently based primarily upon estimations from automaker-supplied data, without critical analysis, vetting, or sharing of the necessary data to substantiate the changes and real-

world benefits by the agencies. If the automakers and the agencies are not willing to provide make-and-model specific data for all these vehicle technologies in the 2015 and 2016 fleet to provide substantiation of the technological changes, the agencies will have acted inconsistently, and will remain highly susceptible to the appearance that they have yielded to biased industry data, buried technology in the baseline, and artificially removed applicable future-year technologies (See I.A.11-14)

Another highly cost-effective technology area the agencies have eliminated from use in future model years within this proposed rulemaking is air-conditioning refrigerant emission reduction (See Section I.A.15). Stating their rationale to harmonize the standards, EPA has proposed to exclude air conditioning refrigerants and leakage from average performance calculations after model year 2020. This is inappropriate, as air conditioning GHG-reduction technologies are available, cost-effective, and experiencing increased deployment by many companies due to the standards. As evidence of the technologies' availability and cost-effectiveness, at least 16 companies have deployed some refrigerant leakage-related technologies and received GHG credits. At least four companies are deploying low-global warming refrigerants, replacing the main refrigerant R-134a with HFO-1234yf. EPA fails to acknowledge, much less discuss, these developments. This oversight implies that U.S. EPA engineering experts that administer, review automaker technology, and enforce these provisions have – inexplicably – not been involved. The proposed approach to eliminate these GHG provisions amounts to an incorrect, unsupported, and invalid action that removes about 15 g/mile emission reductions from 2021 on, arbitrarily removes a cost-effective technology and GHG provisions that deliver approximately 16% of the total required g/mile GHG reductions from the existing 2017-2025 rules, and about 40% of the g/mile GHG reductions from just the 2021-2025 model year regulations.

The approach for off-cycle credit technologies is similar to the above ways in which the agencies have falsely and artificially restricted the deployment of technology. Even though this is an area where automakers have demonstrated the most bullish deployment and public positions to deploy more such technologies, the agencies are essentially assuming that the auto industry will continued to deploy off-cycle technologies worth just approximately 2.5 g/mile CO_2 from 2016 straight through to 2025 and beyond. The only reasonable compliance scenario is that the auto companies will each deploy all the off-cycle technologies that other automakers are already deploying in 2016, by model year 2025, based on our analysis that demonstrates the off-cycle technologies are evidently more attractive and cost-effective than many of the test cycle technologies. Thus, for the agencies to have a reasonably plausible scenario for the augural and adopted 2025 standards, they would have to include at least 15 g/mile CO_2 reduction from off-cycle technologies. The technologies are highly cost-effective and being deployed in greater sales penetrations than many of the test-cycle efficiency technologies that the agencies are analyzing. If the agencies do not assess up to at least 15 g/mile CO_2 off-cycle technology use in their compliance assessment of the adopted 2025 GHG standards and Augural 2025 CAFE standards, their compliance scenarios can be dismissed as wholly unrealistic, as they are contrary to current trends and the automakers' stated intentions to pursue far greater off-cycle technology credits.

For the agencies to conduct a credible regulatory assessment they must remove all the technology availability constraints, re-incorporate and make available the full portfolio of technology options as was available in EPA's analysis for the original 2017 Final Determination, and include at least 15 g/mile CO_2 for off-cycle credits by 2025, to credibly reflect the real-world technology developments in the auto industry.

Technology packages and pathways

Based on the ICCT's global analysis of vehicle regulations, the EPA's physics-based ALPHA model used in the mid-term evaluation offers the most sophisticated and thorough modeling of the applicable technologies that has ever been conducted for a vehicle regulation. This EPA model is based on systematic modeling of technologies and their synergies when combined as packages. It was built and improved upon by extensive modeling by and with Ricardo, a global engineering consultancy. It incorporated National Academies input at multiple stages. It has included many peer reviews at many stages of the modeling, and the associated technical reports were published in many technical journal articles and conference proceedings. This previous work in the TAR also used state-of-the-art engine maps based on benchmarked high-efficiency engines.

Despite these rigorous advances in vehicle simulation modeling, it appears that the agencies have completely and expressly disregarded the ALPHA model and its enhancements. Instead, the agencies have used Argonne National Laboratory's Autonomie model and relied upon generally older and less applicable engine maps than the EPA data and modeling that underpinned the original 2016 Proposed and 2017 Final Determination. The input data and methodological choices used in the NPRM are less rigorous, and fewer peer review processes have been conducted to improve the work. The Autonomie model inputs have clear deficiencies as shown by its demonstrably inaccurate projections of efficiency values for individual technologies like turbo-downsized engines, CEGR engines, and stop-start systems, as well as multi-technology synergies among advanced engine, transmission, and hybrid technologies, as described in detail below. The Autonomie model does not include key efficiency technologies like advanced DEAC, VCR, Miller Cycle, e-boost, and HCCI. This is especially problematic as the agencies appear to have available engine maps from IAV on advanced DEAC, VCR, Miller Cycle, e-boost (and from advanced DEAC, VCR, Miller Cycle, e-boost, HCCI from EPA) that Argonne or the agencies have been unable, or decided not, to include in their modeling.

The agencies have failed to defend their decision to abandon ALPHA and its updated inputs and their decision to exclusively adopt Autonomie and its evidently outdated inputs. The only way to have a chance of accurately estimating future technology usage is by using the most up-to-date inputs and realistic modeling available. It appears that the agencies have inexplicably abandoned this approach to the detriment of their ability to competently model the likely scenarios for the 2025 auto industry. By adopting Autonomie, it appears that the agencies have become incapable or unwilling to model advanced technologies accurately, despite EPA's vastly superior model, integration of input data from benchmarked engines on state-of-the-art technologies, and previous analysis on these technologies.

The agencies must conduct a systematic comparison of the Autonomie modeling system and ALPHA model, and state why Autonomie was selected for use over ALPHA's efficiency values for technologies and synergies. Part of this comparison should be to assess how the agencies' model choice of Autonomie versus ALPHA impacts each of the major 2025 technology package synergies and where and why Autonomie provides different results from ALPHA. Because ALPHA is the dominant, preferred, and better-vetted model and was used by EPA in the original Proposed and 2017 Final Determination, the agencies are legally required to assess and describe whether and how the use of the ALPHA modeling would result in a different regulatory result for their analysis of the 2017-2025 adopted GHG and Augural CAFE standards. The agencies must conduct a proper vetting of their NPRM's foundational Autonomie modeling, and must defend why they appear to have chosen to dismiss the superior and better vetted

technology modeling approach with more thorough and state-of-the-art advanced powertrain systems modeling and engine maps from the EPA ALPHA modeling. Unless and until the agencies conduct such a comprehensive and systematic comparison to determine whether the Autonomie modeling is superior to ALPHA, the agencies have no basis on which to use Autonomie, instead of the EPA ALPHA, as the technology package effectiveness input for fleet modeling system. Because the agencies have used the insufficiently vetted Autonomie within their CAFE modeling system in their final rulemaking, it is necessary that the agencies comprehensively model the final regulation in EPA's complete modeling system and share the complete inputs and outputs and allow public comment on that analysis (See Sections I.B.1, I.B.2, I.B.4)

In the construction of packages for the technology sequencing, the agencies have made systematic errors that poorly relate to realistic automaker decisions on adoption of technologies to comply with the CAFE and GHG standards. In the development of the pathways, the agencies have made many systematic errors that artificially and falsely constrain the availability of technologies based on subjective decisions on allowed technology packages. A primary flaw by the agencies is to constrain technologies and technology paths according to the original baseline technologies used on each make and model as mentioned above. This problem is then compounded because the agencies layer on additional subjective and unrealistic constraints on the *combinations* of technologies.

There are many specific cases where viable technology combinations are disallowed by the agencies, despite being deployed by automakers. For example, turbocharging and cylinder deactivation (DEAC) are treated as mutually exclusive by the agencies, as are HCR1 and DEAC. However, as acknowledged by the agencies, these technology combinations are technically viable. Volkswagen's most recent EA211 engine has both cylinder deactivation and uses the Miller cycle, which is, essentially, a turbocharged HCR engine. And Mazda now uses cylinder deactivation and HCR technology on its SkyActiv 2.5L engine. Of course, these are only current examples known in 2018, and many other automakers will continue to combine TURBO, HCR, and DEAC, as well as more technologies when they have cost-effectiveness synergies. It is critical that the agencies do not disallow any such combinations without substantiation, but their current subjective process of determining technology packages in pathways inherently precludes many dozens of such combinations.

Another basic example of an arbitrary agency limitation on technology packages is that the CAFE model disallows the use of cooled EGR on naturally aspirated engines. A naturally aspirated engine, meaning one that is simply not turbocharged, is the dominant engine on the vehicle market today. This constraint is again belied by existing, real-world technology, as the model year 2018 naturally-aspirated Toyota Camry uses cooled EGR (and also HCR) and shows an efficiency improvement beyond the HCR engine.

In order to enable meaningful public comment, and a credible decision-making process, these technology combination and pathway constraints must be explicitly documented and justified, which they are not. Unless and until the agencies justify each and every constraint they impose on any company, technology, and technology combination, the agencies must remove each of their manufacturer-specific, vehicle model-specific, technology-sequencing, and technology-combination-based constraints in their modeling framework. This is necessary in order to have a credible and transparent regulatory assessment that does not obscure any unsupported or possibly biased decisions by agency modelers. If the agencies do determine that their constraints are valid, they must document the reasons for that conclusion, and provide an additional public comment opportunity.

Due to our findings regarding the agencies' incomplete analysis of existing technologies that are on production vehicles, we ask that the agencies do a complete update of their reference dataset to model year 2017. The model year 2017 dataset, including each model's sales, fuel economy, CO_2 emission rates, footprint, and the associated efficiency technologies is in the possession of the agencies due to EPA's data-collection and enforcement responsibilities. The examples we discuss in our comments where the agencies are failing to acknowledge in factual terms what technologies the auto industry is deploying make it necessary that the agencies update their initial reference dataset, re-examine every technology that is on those vehicles, and use the updated 2017 dataset as the new basis for their future year compliance scenarios. This update and sharing the 2017 dataset at a make and model level will ensure the agencies compliance modeling is predicated on up-to-date data and the agencies are not neglecting real-world trends, as with the examples we are sharing in these comments (e.g., related to HCR).

We ask that, based on this update for a complete 2017 dataset, the agencies also provide a rigorous summary table that includes, for each significant efficiency technology used to comply with the adopted and augural future standards, the model year 2010, 2016, and 2017 sales and sales shares of those technologies. We also recommend that the agencies show the percent increase from 2010 to 2017, and from 2016 to 2017 for each technology, to show that the technologies (some of which they are constraining from use in their modeling) are being deployed in increasing numbers in the marketplace. We also ask the agencies to disclose the efficiency technologies that the automakers have disclosed will be on production vehicles by 2025 (without naming automaker names, to avoid disclosing confidential business information). If the agencies do not do this, it would appear (based on our analysis of auto industry announcements) that the agencies are not fully disclosing information in their possession that is contrary to their own subjective technology constraints.

Technology cost and cost effectiveness

Overall, the modeled compliance cost of achieving the Augural 2025 NHTSA standards and the adopted 2025 GHG standards as assessed in the 2018 NPRM have increased by 50-100% from the joint-agency Draft TAR from 2016, and by over 100% from EPA's original 2016 Proposed Determination and 2017 Final Determination. This invalid high cost result was created by the agencies by making many dozens of unsupported changes in the technology effectiveness and availability inputs, the technology cost inputs, and the technology package constraints. The underlying decisions, assumptions, and constraints causing such high modeled compliance costs have largely been obscured from public view. To the extent possible during the agencies' limited public comment period, the ICCT has attempted to discern and decipher the modeling code, hard-coded algorithms, subjective modeling decisions, and technology inputs from the agencies datafiles to understand all the changes, and we provide comments on our findings regarding the agencies' cost assessment here.

In terms of the cost of individual efficiency technologies, the agencies failed to capture the latest available information and, as a result, their assessment incorrectly and artificially overstates technology costs. Based on our analysis of the NPRM and its supporting information, and comparing it with best available information elsewhere, we point out several examples that illustrate how and where the agencies have failed to include the most accurate and updated information in their rulemaking. We note that these examples are not exhaustive but reflect the understanding we have been able to gain in the limited public comment period. These examples include variable valve timing, turbocharged downsizing, cooled EGR, where agency costs are generally 30% to 100% higher than best available estimates from automakers' and suppliers'

current real-world developments in 2018 (as analyzed by the ICCT and by the EPA). Other examples, one being advanced cylinder deactivation, the agency costs are even more exaggerated, by over 100%, based on the industry-developed innovations being far simpler than the agencies have assessed. The agencies also fail to reflect the findings from the best-available technology studies, which clearly indicated that a 5-10% mass reduction by 2025 actually reduces vehicle cost, and the auto industry will cost-effectively deploy at least 15% vehicle curb mass reduction in the 2025 timeframe at near zero net cost (and consistently less than $500 per vehicle) if the Augural 2025 and adopted 2025 GHG standards are maintained. Overall, the NPRM compliance costs are much higher than EPA's original 2016-2017 Final Determination as well as ICCT's estimates, and there are no overall or specific justifications to support all of these significant individual technology differences that lead to the major discrepancy. Nor do the agencies explain their failure to use the up-to-date technology information that shows lower cost. (See Section I.C.1).

The agencies' errors in analyzing costs extend beyond the individual technology cost inputs to how they handle the selection and sequencing of technologies according to cost-effectiveness. In the construction of packages for the technology sequencing, the agencies have made systematic errors that do not reflect realistic automaker decisions on adoption of technologies to comply with the CAFE and GHG standards. Our analysis of the inputs and the outputs demonstrate a deeply flawed logic with nearly no quality control steps to ensure realistic sequencing of technology adoption that reflects best available data on technology costs and effectiveness.

The first such technology sequencing problem is that the agencies follow the Volpe CAFE approach with dedicated mutually exclusive paths that allows for no "off ramps" for companies to ever change to many of the available and emerging technologies. Once a company's vehicle models are on a specific path, they are forced to advance through what the CAFE modelers have determined as that specific future powertrain's sequence of technology applications, without regard to effectiveness or value. A consequence of these fixed pathways is that the various vehicle models often do not select the most optimal cost-effective technologies by 2025. The more general related issue is that technologies are not applied to a vehicle based solely on cost-effectiveness (cost per fuel consumption or GHG improvement). Rather they follow a subjective modeler-constrained path as chosen by NHTSA CAFE analysts, unlike the previous objective cost-effectiveness-determined path by the EPA OMEGA fleet modeling approach. Therefore, some technologies add no or negative efficiency benefits at significant costs but are added anyway solely due to the fact that they have been placed as the next in line.

We provide several examples from our analysis that show how the agencies' CAFE model is working in its 2018 NPRM analysis, based on its inputs and algorithms. First, based on the inputs and model outputs, cooled exhaust gas recirculation (CEGR) is incorrectly modeled in the agencies' datafiles. CEGR, added to TURBO2, has an assigned 0.0% effectiveness (a faulty Autonomie input) with $359 cost in 2025. This would thus add zero value to any automaker, yet the Augural 2025 analysis of the CAFE model forces CEGR on 38% of the new model year 2025 fleet. When we at the ICCT simply block CEGR from use in the CAFE Volpe model, the result is to reduce the cost of compliance with the 2025 Augural standards by $116, on average across all new vehicles in model year 2025. This is an inexplicable result, as the CAFE model claims it is designed to choose the most cost-effective technology pathway for compliance. This is clearly not the case, as removing technology choices should never reduce the cost of compliance. This profound error reveals a CAFE modeling approach that is poorly vetted and not competent to reflect the real-world, in which auto companies will only choose cost-effective

technology approaches. As already pointed out, the agencies chose to run a sensitivity case which they activated HCR2—a highly cost-effective technology—in the CAFE model. This one change alone reduced the cost of compliance with the Augural 2025 standards by approximately $600. In another example of the flawed cost modeling, the benefits of the second level of turbocharging (TURBO2) over the first level (TURBO1) vary widely in the agencies' modeling, with the benefit of TURBO2 over TURBO1 sometimes being negative. It is implausible for the more advanced TURBO2 package to be less effective than TURBO1, when each has all the same additional efficiency technologies included as a package. This appears to be a clear modeling deficiency without any real-world justification both in the Autonomie vehicle modeling and the CAFE fleet modeling, which both carry this error through the regulatory analysis. This is simply not a sensible result, as automakers would never add a next-generation technology that has significant cost but a negative effect on CO_2 and fuel economy. Yet the agencies' modeling includes penetration of TURBO2 regardless, demonstrating poor modeling and no vetting for whether the results have real-world validity. (See Section II.B.2)

The agencies have apparently misrepresented the leading research on automotive battery costs and electric vehicle costs generally. The result of this is to make electric vehicles so costly that they are modeled to remain at approximately the same penetration in 2025 with the Augural 2025 fuel economy and adopted 2025 GHG standards, as they are in mid-2018 (i.e., between 1.5% and 2% of new vehicle sales). The agencies' analysis of electric vehicle costs and the resulting extremely low penetration levels is not in line with automakers' announcements, which include statements that they will produce far greater numbers of electric vehicles to comply with standards around the world. The agencies' sensitivity case that puts its electric vehicle technology cost inputs in line with best available research, demonstrates this; with reasonable electric vehicle costs, the 2025 compliance costs fleetwide decreased by over $200 per vehicle.

More generally, it is evident from the above that the agencies' modeling is not a credible effort to project compliance scenarios that minimize the cost of compliance by industry in their future-year compliance scenarios. In fact, their various technology constraints (in technology effectiveness, cost, and manufacturer/model/pathway-specific restrictions) all seem expressly counter to seeking the most cost-effective industry compliance paths. As a result, it is necessary that the agencies explain in detailed, categorical, and unequivocal terms how their modeling framework seeks to identify the most cost-effective viable technology paths for companies to comply with the standards, and that they make all the necessary changes to fix the issues above to assure their modeling effort provides a reasonable approximation of auto industry compliance with future-year standards. At a minimum, the agencies must also include modeling using EPA's OMEGA and ALPHA models, and not just CAFE and Autonomie modeling, to help avoid the inappropriate elements of the CAFE modeling described above and in more detail in the Appendix.

Baseline modeling approach

The agencies have made an inappropriate decision to artificially reduce the benefits of the existing GHG and augural CAFE standards by subjectively adjusting their vehicle fuel economy and GHG emissions in the future reference fleet. The agency decision to assume continually improving fuel economy even in the absence of more stringent standards for their regulatory benefit-cost accounting wholly misrepresents available historical evidence, and it shows the agencies are not utilizing the extensive analysis from EPA and the research literature on this topic.

There are decades of clear historical data to inform the analysis of how to treat baseline fuel economy when standards are not increasing. The data clearly and unambiguously demonstrate that without regulations that require more stringent fuel economy or GHG standards, fuel economy will not increase and GHG emissions will not decrease. Only in periods where fuel economy or GHG standards have required improvement, improvements in test cycle fuel economy have occurred. Based on the EPA and NHTSA data, from 1975 to 1986, US fuel economy increased with more stringent standards. When standards did not get more stringent, from 1986 through 2004, no fuel economy and GHG benefits were realized, and in fact fleet fuel economy worsened. With the adoption of California's GHG standards in 2004 (for model years 2009-2016), and NHTSA light-truck fuel economy standards in 2002 (for model year 2005), fuel economy improvements resumed.

This phenomenon has been very well studied in the technical literature. What happens during periods without required fuel economy improvement is that the industry deploys advanced engine, transmission, and load reduction technology, but they use these technologies mostly or exclusively to make higher-power, greater-acceleration, and larger vehicles. The agencies' expert staff that handle and analyze this data know very well that this is the case, as they have a robust 45-year record in the EPA fuel economy trends database, as well as from NHTSA's comparable data that is derived from EPA's official compliance data. From the ICCT's extensive analysis across the world, we know that internationally the same general result has held true. The only times we have observed any multi-year real-world fuel economy or CO_2 improvement trends in the absence of stronger regulations was in European markets in the lead-up to 2010, when both fuel prices were several dollars higher per gallon than in the U.S., and automakers had instituted voluntary CO_2 targets in lieu of standards for new 2010 passenger vehicles. Even there, regulators recognized the need for oversight, and the gains led to Europe developing CO_2 regulations to ensure even more verifiable emission reductions occurred.

Despite this history, the agencies have made a novel and indefensible decision to assume that the fleet will realize improved fuel economy and GHG emissions reductions even when standards are flat due to the proposed rollback of standards for 2021 and beyond. The result of the agencies' unfounded adjustment in the baseline, based on our analysis, is that the agencies are artificially removing over 20% of the GHG and fuel saving benefits that would result from maintaining the adopted model year 2025 GHG and Augural CAFE standards. The decision to assume an increasing efficiency even in the rollback scenario also has a result that would appear rather inconvenient to the agencies: It directly contradicts the agencies' claim that their proposed flat 2021-2026 standards are the "maximum feasible." (see Section II.A)

Fleet rebound and safety

Despite the compelling record on this issue to the contrary, the agencies project relatively large increases in traffic fatalities from the augural standards for 2021 through 2026. These projected additional fatalities are used as a basis for freezing the CAFE and GHG standards for 2021 through 2026. The agencies finding is in direct opposition to U.S. trends, which show improvements in both vehicle efficiency and safety driven by government policy.

In perhaps the one science-based bright spot is the agencies' attempt to correctly model the impact of the vehicle regulations on safety, the agencies made progress in their assessment of automotive mass reduction technology's impact on safety. The agencies have, within the 2018 NPRM, finally recognized that any link between vehicle weight and safety is statistically

insignificant. The agencies recognize that the link is just as often positive as negative due to automakers' exemplary vehicle design improvements over the years.

However, the agencies have made some of the most inexplicable moves that we have ever seen across U.S. and global vehicle regulations by employing two tricks that artificially and falsely create a link between increased fuel economy and fleet fatalities.

The first trick is that the 2018 NPRM doubled the rate used to calculate the "rebound effect" compared to their prior analyses from 10% to 20%. By doubling the rebound rate, the agencies claim that under the existing/augural standards, Americans will buy higher-efficiency cars and drive those cars at a greatly increased rate because they are cheaper to drive. This doubling of the rebound effect is in contradiction to both theory and data trends. Studies the agencies rely on for their new assumption are typically based on changes in fuel price, not changes in vehicle efficiency, and these studies overstate the rebound effect associated with fuel efficiency. Moreover, even studies of fuel price rebound indicate that the rebound effect has been decreasing over time. The agencies' evaluation of the rebound effect in the 2016 TAR (and in EPA's final 2016 TSD) more appropriately considered these effects - based on the *same* studies discussed in the NPRM – and, found that a 10% rebound effect was appropriate. Based on the most reliable data, the fuel price rebound effect will continue to decrease in the future and is likely to be well under 10% by 2025, and the fuel economy rebound effect may be lower still. Thus, the agencies cannot support the use of a higher value in their proposal. (See Section II.B.2)

While the rebound effect is real, owners would not drive more if they did not perceive economic benefits to the additional driving, which include their consideration of the accident risk of driving more. In fact, the agencies admit in the NPRM that Americans choosing to drive more and the accident risks that driving carries should not affect the analysis of the costs and benefits of the standards, because when people drive more, they do so because they are benefiting from the driving—in their words, it is a "voluntary consumer choice." The agencies have chosen to separate the additional accidents from the economic benefit of increased driving in the rule, creating a "loss" associated with additional accidents and fatalities balanced by an "economic benefit" of exactly the same dollar value. This allows the agencies to quote the additional fatalities and use them as justification for freezing the standards, while hiding the associated economic benefits deep in the details of the proposed rule.

The second trick is that the agencies have created a new, untested, and ultimately erroneous "scrappage model" of used car impacts to suggest that the regulation will cause more driving of older, less safe vehicles. They attempt to model immensely complex market interactions in an entirely new and simplistic way, and they do so with completely unvalidated methods which have not been peer reviewed or apparently even internally reviewed with any rigor. The NPRM, as indicated in these comments above, dramatically exaggerates the compliance costs of the adopted GHG and Augural CAFE standards. These exaggerated costs are then plugged into the agencies' new vehicle scrappage model to project scrappage effects. The modeling then inexplicably projects a dramatic increase in the number of used cars in the vehicle fleet under the existing GHG and augural CAFE scenario, and a dramatic increase in the total number of vehicle-miles being driven, which, when multiplied by the agencies' fatalities-per-mile figures, allow the agencies to ultimately assert that there will be more fatalities. By artificially revising rebound rate and arbitrarily asserting scrappage effects, the NPRM projects that both *new* and *existing* cars are going to be driven much more if standards are increased, which defies logic and economic theory. The error is then compounded because, unlike the rebound driving that the agencies admit is due to consumers voluntarily driving more and is not caused by the

standards, the agencies claim the scrappage-related increase in fatalities *are* caused by the standards. Just like rebound, the scrappage "costs" of the augural CAFE and existing GHG standards result (if at all) from consumers' freely-made decision to drive more, and those decisions are similarly attended by consumer benefits that at a minimum exceed the costs of that driving. Therefore, just like rebound, these "costs" cannot be attributed to the rule.

This mysterious, incredible increase in driving of existing vehicles biases the cost-benefit analysis by as much as $120 billion in reduced fatalities and non-fatal crash injuries. Including the impacts from the associated, alleged reduction in congestion and noise from this driving inflates the agencies' estimated effect by another $52 billion. The agencies are citing these alleged reductions in fatalities and associated effects—from essentially forcing Americans to drive less—as the primary reason they need to roll back the CAFE and GHG standards.

This scrappage-related cost-benefit analysis trick is so novel that NHTSA, in its many dozens of safety-focused regulations (which also add cost to vehicles) over the years, has never assessed or created any such model to do any such analysis, nor does it appear to have even mentioned the possibility of doing so. The attempt to estimate these effects was developed specifically, and apparently hastily with no chance for a comprehensive peer or other review, for use in the 2018 proposed rollback of the CAFE and GHG standards. For the agencies to put forward a credible final regulation on vehicle fuel economy and GHG regulations, they have no choice but to remove the scrappage-related fatalities and associated costs. If the agencies do not remove the artificial scrappage-related fatalities and associated costs, NHTSA, the nation's vehicle safety regulator, will cast into doubt its own expertise and credibility. (See Section II.B.3)

Consumer value

The NPRM continues a long-standing error of failing to consider the complete spectrum of benefits from efficiency technologies that are valued by drivers beyond the efficiency benefits. This failure is becoming more glaring over time, as efficiency technology deployment continues to add more attributes consumers are willing to pay for. The most common benefit is improved performance and drivability. One example is that adding more gears to the transmission improves maximum acceleration, improves launch feel due to a lower gear ratio in first gear, reduces noise on the highway by running the engine at lower speed, and reduces vibration and harshness by reducing the change in engine speed between shifts. Examples in automotive trade literature indicating these clear co-benefits include the Ford F150, Ford Mustang, Chevrolet Camaro, Honda Accord, and Lexus LC500. Variable valve timing (VVT), variable valve lift (VVL), and gasoline direct injection (GDI) technologies increase engine power in addition to improving efficiency. Also the higher-voltage, higher-power electrical systems on 48-volt hybrids offer many potential consumer features desired by customers, such as part-time 4wd, off-board power, heated seats, and other electric amenities. Examples of automakers marketing 48-volt systems for their efficiency and these additional types of benefits are the Dodge Ram and Jeep Wrangler.

Other prominent examples of efficiency technologies delivering dual benefits are turbocharged engines and vehicle mass reduction. Downsized, turbocharged engines are usually sized to maintain constant power at high engine speed. However, even within these constraints, turbocharged engines can deliver their maximum power at lower engine speeds than naturally aspirated engines and have more torque at lower engine speeds. Examples from the trade literature regarding the dual fuel-saving and power benefits include the BMW Mini, Jeep Wrangler, Ford F150, Ford Mustang, and Honda Accord. Mass-reduction or lightweighting has

many benefits beyond fuel savings, including faster acceleration, better ride, handling, braking, increased towing capacity, and greater payload capacity. In addition, aluminum, a common mass-reduction strategy, will not rust. Magazine reviews including these additional benefits include BMW 7-series, Chrysler Pacific, Cadillac, and Chevrolet Cruze. These are just examples of the nearly countless instances of automakers simultaneously marketing fuel efficiency technologies and non-efficiency benefits from those technologies. (See section II.C)

The agencies have falsely ignored these very substantial benefits. If the agencies considered these effects, they would find additional vehicle benefits that they are currently not accounting for in the rulemaking. These benefits would also further counter the agencies' erroneous assertion that increased fuel efficiency will result in depressed vehicle sales.

Regulatory certainty and investments

Beyond our objections on the benefits and costs, the agencies have failed to recognize additional social costs that the proposed regulation will impose. If the proposal goes forward, cities and states throughout the U.S. with obligations to clean air and climate change mitigation will be forced to achieve their reductions by other means. Subnational governments will be forced to use new and additional policies to recover the lost environmental benefits. States and cities that oppose the proposed rollback now account for 55% of the U.S. auto market, and these states and cities are ready to litigate against the federal rollback. To meet their clear air and climate requirements, these jurisdictions are ready to adopt stronger local policies that could be far more complicated for the auto industry if the proposed federal rollback goes forward. With the proposed freeze on national standard stringency from 2020 on, the cost to the industry will be realized in hugely uncertain and unpredictable ways. As the processes and legal decisions on these standards drag out, they will cause subnational governments to use new and additional policies to recover the lost environmental benefits. (See Section III).

In addition to jeopardizing existing automotive technology investments across the country, the agencies are not appropriately accounting for the massive employment opportunities that result from the fuel savings from fuel economy and GHG regulations. The NPRM analysis failed to analyze how supply chain innovations are induced by the regulations and how fuel savings give consumers more money to spend on other goods and services, and therefore have additional indirect economic benefits. The NPRM did indeed model how the proposed rollback would result in a loss of 50,000 jobs per year by 2021 and 60,000 jobs per year by 2023. However, the full economy-wide employment gains from supply chain technology innovations and economy-wide benefits from the fuel savings—amounting to more than 300,000 jobs by 2035—were ignored. This jobs figure is based on a major Indiana University study originally contracted by the Alliance of Automobile Manufacturers that was submitted to the docket. The agencies failed to even mention this study or include any discussion of job impacts from reduced fuel expenditures. It is inexplicable why the agencies would want to destroy over 300,000 jobs by rolling back the efficiency standards as proposed. (See Section III).

International competitiveness

In addition, the agencies fail to comprehend how the indefinite relaxation of the standards would jeopardize the U.S. automotive industry. The agencies have not even compared the U.S. proposal to progress elsewhere around the world, such as in Europe, China, and other countries where vehicles continue to get more efficient due to significant regulatory requirements and

steady industry progress in those markets (including industry progress achieved by many of the same companies subject to regulation under the proposal). In the near-term, the proposed rollback will strand existing investments and prevent new investments in the U.S. by suppliers and automakers. Over the long-term the greater risk is that U.S. industry becomes unfit to compete in a global market that is moving to low-emission and high-efficient vehicle technology. (See Section IV)

Zero emission vehicles

The agencies sought comment on "the extent to which compliance with the ZEV mandate frustrates manufacturers' efforts to comply with CAFE standards." The agencies' proposed approach to remove the authority of California and other states on low-emission vehicles is profoundly shortsighted. In 2018, the global auto market is at the early stages of a significant and unprecedented transition to an alternative fuel vehicle technology. This transition of course is toward zero-emission electric vehicles.

Nearly every major automaker has, in some form or another, publicly indicated that they believe the future of the automotive industry is electric. These automakers include Audi, BMW, General Motors, Mercedes Benz, Mitsubishi, Nissan, Porsche, Renault, Škoda, Tesla, Toyota, Volkswagen, and Volvo. Many automakers have publicly shared details on their plans for an electric future, including targets and a timetable. The automakers' announcements for electric vehicles total $200 billion in electric vehicle investments and over 15 million electric vehicle sales per year by 2025. This increase in electric vehicle sales, based on automakers' announcements, amounts to an order of magnitude increase in 8 years. These announcements signal the timing to cross the proverbial "valley of death" to where electric vehicles ultimately reach significant production volume and achieve economies of scale needed for profitability.

Electric vehicles are primarily manufactured in the region where they are sold. If the U.S. wants to be on the leading edge of the transition to electric vehicles—from an *industrial* perspective—it will need to support the growing U.S. electric market. However, the proposed rollback to the CAFE and GHG standards, and especially by withdrawing state authority to protect their air and the climate, would do the opposite of this. The proposal would strike a blow, not just to environmental goals, but also to long-term U.S. automotive leadership in new electric-drive technologies that nearly every automobile company leader is affirming are their future.

The agencies' proposal would virtually guarantee that the U.S., and its automotive industry in particular, is not playing an integral role in the world's long-term transition to zero-emission mobility. With the agencies' proposal, U.S.-based auto companies would be increasingly vulnerable over the long-term as a global shift to electric vehicles passes it by.

Yet, the California-initiated Zero-Emission Vehicle regulation has kept the U.S. vehicle market apace with the global transition to electric vehicles. California alone amounts to half of U.S. electric vehicle sales with electric vehicle uptake that is over 5 times that of the rest of the U.S. Including the nine other adopting states, the ZEV regulation account for nearly two-thirds of U.S. electric vehicle sales.

The immense progress to date to grow the U.S. electric vehicle market was, in part, because the federal government, California, and the auto industry were willing to come together in 2011 to agree on stable long-term standards to 2025. It was also in large part due to the leadership of California and other states in utilizing their authority to implement their regulations and the supporting policy to help meet their longstanding clean air and climate commitments. We

recommend the agencies do not revoke the California waiver and take no action toward removing state-level regulatory authority. (Section V).

Summary

Overall, the agencies' rationale for their proposed rollback is invalid and unsupportable by the best available data and methods. The EPA has not shown that the GHG standards for 2022-2025 are inappropriate under the Clean Air Act or the agencies' own Midterm Evaluation regulations; nor that the proposed standards or any of the alternatives considered are appropriate. Similarly, for the multitude of reasons discussed above and demonstrated below, the National Highway Traffic Safety Administration's proposed freeze on post-2020 corporate average fuel economy (CAFE) standards does not satisfy the agency's obligation to set standards that are the "maximum feasible" for 2021-2026 as dictated by statute. To the contrary, the agencies have failed to acknowledge, discuss, or rebut the expert assessments and robust analysis previously put forward jointly by the U.S. EPA, NHTSA, and California Air Resources Board in their Draft Technical Assessment Report, an analysis which demonstrates definitively that the standards remain appropriate, and that any rollback is without justification.

Perhaps most problematic among the many issues is that the agencies did not apply their own applicable and best available data. In 2015-2017, the agencies developed and assembled an immense amount of new data, evidence, information, and analysis related to technology developments that have occurred since the 2012 rulemaking. This analysis culminated in the 2016 Draft TAR and EPA's 2017 Final Determination. The level of technical scrutiny by the agencies, especially EPA, in 2015-2017 for a vehicle regulation is, as far as the ICCT is aware, unprecedented globally by a very large margin. Yet EPA and NHTSA have together ignored this massive and rigorous technical analysis almost entirely, instead adopting input and model constraints directly contrary thereto, generally without acknowledgment or explanation. This new data and other information from continued technology developments clarify and show how the standards are achievable and at lower cost than projected. The summarized comments above, and details in the attached Appendix illustrate how the agencies' analysis is biased, incomplete, and opaque in its omission of best available information, including data that is known to be in their own possession due to extensive public research, compliance data, and the previous rulemaking documents.

Contrary to the agencies' suggestion, the agencies' own abundant technical evidence demonstrates that the standards could be cost-effectively made more stringent. Nevertheless, in the interest of maintaining regulatory certainty for industry investments, we believe that maintaining existing adopted GHG standards for 2022-2025 is appropriate. Furthermore, we strongly urge NHTSA to finalize its Augural 2022-2025 standards to ensure alignment with the adopted EPA and California 2022-2025 standards.

In the Appendix that follows, we elaborate on the agencies' series of unacknowledged and unsupportable departures from the rigorous 2015-2017 technical analysis and the proposal's arbitrary adoption of erroneous, outdated, unsupported, and invalid data and methods, and we suggest improved data and methods from which to make an appropriate regulatory analysis.

APPENDIX: DETAILED COMMENTS

The International Council on Clean Transportation (ICCT) provides these comments to *The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021-2026 Passenger Cars and Light Trucks*, which proposes to revise the model year 2021–2026 light-duty vehicle greenhouse gas (GHG) emissions and corporate average fuel economy (CAFE) standards. This Appendix supplements the shorter summary of the ICCT's public comments, with additional details and references to the public comments above.[1]

I. Technologies inputs and modeling methods

This section discusses the agencies' technology assessment related to its consideration of GHG and CAFE standards. The section includes subsections on technology availability and effectiveness, technology packages in the technology pathway modeling approach, and technology cost and cost-effectiveness assessment.

Our comments are based on available technologies in the market today, announcements by automakers and suppliers on emerging technology, and the research literature. Much of the research contribution is from ICCT collaborations with automotive suppliers on a series of working papers in 2016, evaluating technology progress and new developments in engines, transmissions, vehicle body design and lightweighting. The collaborating supplier and research groups include Aluminum Association, BorgWarner, Dana, Detroit Materials, Eaton, FEV, Honeywell, ITB, Johnson Controls, Ricardo, and SABIC. In addition, ICCT extensively analyzed the technology inputs to, and the outputs from, the Volpe CAFE model, both for the NPRM and the TAR. We also compare the latest work with many of the rulemaking documents and data inputs from the agencies previous work, including the inputs and outputs for EPA's ALPHA and OMEGA modeling, and the associated benchmarked engine data. These allowed us to assess the technology cost and effectiveness inputs used by the Volpe CAFE model, as well as the technology penetration rates and overall cost, GHG, and mile-per-gallon (mpg) data.

A. Technology availability and effectiveness

The agencies have ignored their own rigorous 2015-2017 technological assessment, and have adopted a series of invalid and unsupportable decisions which artificially constrain the availability and dramatically under-estimate levels of effectiveness of many different fuel economy improvement and GHG-reduction technologies and unreasonably increase modeled compliance costs. These include powertrain technologies, load reduction technologies, air-conditioning technologies, and off-cycle technologies.

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[1] *These comments, and their attachments, refer both to the EPA GHG regulations and the DOT NHTSA CAFE regulations throughout. Even as the detailed comments below may at times refer to only the NHTSA CAFE or EPA GHG standards separately, each such instance shall be read as applicable and warranting consideration for the regulatory provisions in both programs.*

1. *High compression ratio engines*

Perhaps the foremost example of the agencies incorrectly constraining technology in the NPRM is for high compression ratio (HCR) engines. The agencies constrain this technology in two ways: by restricting its availability for uptake in the fleet and by ignoring improvements and developments by the automotive industry since 2014.

In the 2012 Final Rulemaking, the use of Atkinson cycle engines was primarily considered only in hybrid-electric vehicle applications.[2] Later, in the 2016 TAR, the agencies observed that this was because, in 2012, hybrids were the only mechanisms used to overcome low-end torque losses associated with the shift to an Atkinson Cycle.[3] Thus, in 2012, application of Atkinson cycle engines in non-hybrids was "unforeseen."[4]

However, just two years into the 2012-2016 GHG program, Mazda employed Atkinson cycle as the foundation for the first non-hybrid HCR naturally aspirated engine (at a compression ratio of 13.0:1 in the US) with exceptional efficiency and is already using this on most of their vehicles.[5] Toyota has maintained strong vehicle performance by combining an Atkinson cycle engine with variable valve timing and other technologies, and has also expanded its use to non-hybrid vehicles.[6] HCR engines, as of model year 2016, were on diverse models, including many hybrids (by Toyota, Ford, Hyundai, Chevrolet, Nissan), and also non-hybrids like the Toyota Tacoma pickup, Lexus RX350 SUV, Lexus GS 350 luxury sedan, and many Mazda cars and SUVs.[7] In total HCR engines made up over 1 million U.S. vehicle sales in model year 2016, or 6% of total U.S. sales.[8] Comparing this against the model year 2015 data of 4%[9], deployment of HCR engines has expanded their market share in model year 2016 by approximately 50%.

In the 2016 TAR, the agencies described HCR engines as "one of the most promising non-electrified technologies capable of playing a major role in compliance with the standards through 2025."[10] From the 2012 FRM to the 2016 TAR, EPA shifted from a projection of 0% HCR to 44%

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2 *See e.g., 2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards, 77 Fed. Reg. 62624, 62864 (Oct. 15, 2012).*

3 *See EPA, NHTSA, CARB. Draft Technical Assessment Report: Midterm Evaluation of Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards for Model Years 2022-2025 at 5-31.*

4 *EPA, NHTSA, CARB. Draft Technical Assessment Report: Midterm Evaluation of Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards for Model Years 2022-2025 at 5-1.*

5 *Goto et al. "The New Mazda Gasoline Engine Skyactiv-G." MTZ worldwide Issue no.: 2011-06: 40-46. Accessed June 2016. https://link.springer.com/article/10.1365/s38313-011-0063-8*

6 *"Toyota claims record gasoline efficiency." Ricardo Quarterly Review Q2 2014, p. 4. Accessed June 2016. http://www.ricardo.com/Documents/RQ%20pdf/RQ%202014/RQ%20 Q2%202014/RQ_Q2_2014_English.pdf*

7 *See datafiles at National Highway Safety Traffic Administration, 2018, "Compliance and Effects Modeling System." https://www.nhtsa.gov/corporate-average-fuel-economy/compliance-and-effects-modeling-system*

8 *See datafiles at National Highway Safety Traffic Administration, 2018, "Compliance and Effects Modeling System." https://www.nhtsa.gov/corporate-average-fuel-economy/compliance-and-effects-modeling-system*

9 *EPA. Technology and Benefit-Cost Analysis files. https://www.epa.gov/regulations-emissions-vehicles-and-engines/optimization-model-reducing-emissions-greenhouse-gases*

10 *See EPA, NHTSA, CARB. Draft Technical Assessment Report: Midterm Evaluation of Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards for Model Years 2022-2025 at 12-35 also at 5-4, 5-31.*

HCR engines for a compliant 2025 vehicle fleet.[11] Despite the rapid introduction of HCR engines and the higher market penetration projected by EPA in the 2016 Draft TAR, the agencies have dramatically reversed course in the NPRM. They now argue that only "a few" manufacturers produced HCR1 engines in model year 2016 and that these engines tended to be paired with hybrid technologies.[12]

The agencies state that the technology "is not suitable for many vehicles due to performance, emissions and packaging issues, and/or the extensive capital and resources that would be required for manufacturers to shift from other powertrain technology pathways (such as turbocharging and downsizing) to standalone Atkinson cycle engine technology."[13] The agencies also suggested that HCR is not suitable for 6- or 8-cylinder engines.[14] The agencies' own data proves this is false: HCR technology is already used on V-6 versions of Lexus GS 350, GS 350 F Sport, Lexus RX 350, Lexus 450h, Toyota Tacoma. These include non-hybrid models, pickup trucks, performance sedans, all-wheel-drive versions, four-wheel-drive versions, and mid-sized SUVs, and they deliver high-performance with up to 311 horsepower with the Lexus GS 350 and 424 horsepower with the Lexus 450h. Despite these developments that indicate there are not limitations, the agencies have largely restricted HCR technology to the existing Mazda and Toyota models (and select hybrids) that already have it, and the agencies' revised fleet penetration for naturally-aspirated HCR engines is only 26% to meet the Augural 2025 standards, and just 17% for the proposal to freeze post-2020 standards.[15] There is essentially no evidence or analysis to support restricting this technology or why some automakers would opt not to adopt a clearly cost-effective technology.

The agencies' own modeling, based on their effectiveness and cost inputs,[16] shows that HCR technology is one of the most cost-effective pathways to comply with the standards. According to the agencies' primary modeling in the agencies' proposal, nearly all the vehicles that the agencies' model allows to have HCR technology do indeed adopt HCR technology (30% of the fleet is allowed to apply the technology, and 26% of the fleet has the technology applied in the modeled standards for the adopted 2025 standards). This demonstrates how the agencies have restricted the use of a known cost-effective technology.

This restriction on HCR is inconsistent with historical developments on engine technologies, based on data to which the agencies have complete access. Constraining HCR in their 2018 modeling of 2025 compliance is like restricting all manufacturers that did not yet have

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11 *EPA, NHTSA, CARB. Draft Technical Assessment Report: Midterm Evaluation of Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards for Model Years 2022-2025. at 12-35.*

12 *The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021–2026 Passenger Cars and Light Trucks, 83 Fed. Reg. 42986, 43038 (Aug. 24, 2018).*

13 *83 Fed. Reg. at 43038.*

14 *Ibid.*

15 *Id. at 43316.*

16 *Based on NHTSA datafiles. National Highway Safety Traffic Administration, 2018, "Compliance and Effects Modeling System." https://www.nhtsa.gov/corporate-average-fuel-economy/compliance-and-effects-modeling-system and also PRIA Figure 6-119 p 312 HCR1 tends to have a 12% effectiveness (range from 10-16%). For costs see Section I.C. below.*

turbocharging or hybrids just eight years ago from deploying any of them today (e.g., in 2010 versus 2018), which would have been wildly incorrect.[17] The HCR constraint is an assumption with no foundation in the real-world. In fact, in the 2016 TAR, NHTSA projected that Toyota would not use HCR engines, with all 2025 scenarios having less than 1% market penetration.[18] This projection completely missed Toyota's introduction of improved HCR engines on the 2018 Camry and announcement of plans to spread this engine across their fleet.[19,20 21] NHTSA has corrected this for the NPRM and projected that 64% of Toyota's fleet will use HCR engines by 2025.[22] However, if NHTSA could be so wrong about Toyota just two years in advance, there is no justification to continue to restrict HCR engines for other manufacturers for another 8 years based solely on the fact that they had not yet adopted the technology in MY 2016.

The agencies' own data is contrary to this limitation. The agencies' model year 2016 datafile in fact reflects the real-world trend that automakers have tended to first refine their application of HCR by applying the technology to hybrids, and then adopt the technology more widely. Mazda and Toyota have launched broader deployment beyond hybrids into non-hybrid models across their fleets, including high-performance applications such as luxury cars, SUVs, and pickups.[23] Ford, General Motors, Hyundai, and Nissan, have also now embraced HCR in their hybrid models, demonstrating that deployment across the rest of their fleets is possible. Yet the agencies artificially prohibit this broader application for all of these automakers without reasoned support for doing so.

The constraints placed on HCR deployment appear to be uniquely restrictive among all technologies included in the Volpe CAFE model, disallowing this proven and cost-effective technology from approximately 70% of the model year 2020-2025 fleet. The great lengths the agencies have gone to artificially impose "skip" constraints for HCR in the CAFE modeling system demonstrates that the agencies have exerted an inexplicable and apparently deliberate

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17 *Based on the agencies' data, in 2008 there were 5 companies with turbocharging (FCA, Ford, General Motors, JLR, VW), but by 2016 there were 13 (BMW, Daimler, FCA, Ford, General Motors, Honda, Hyundai Kia, JLR, Nissan, Subaru, Toyota, Volvo, VW). See Table 3 below for these and many other such examples of expanded engine technology adoption across manufacturers over the same timeframe, showing that the agencies' artificial manufacturer constraints are unwarranted based on their own data.*

18 EPA, NHTSA, CARB. Draft Technical Assessment Report: Midterm Evaluation of Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards for Model Years 2022-2025

19 *John German "How things work: OMEGA modeling case study based on the 2018 Toyota Camry" February 21, 2018. https://www.theicct.org/publications/how-things-work-omega-modeling-case-study-based-2018-toyota-camry*

20 *Toyota introducing new powertrain units based on TNGA; transmissions, engine, hybrid system, 4WD. http://www.greencarcongress.com/2018/02/20180226-toyota.html*

21 *Camry's engine tech will spread across Toyota; Powerplant boosts performance and efficiency. AutoNews. August 1, 2017. http://www.autonews.com/article/20170801/OEM01/170809949/camrys-engine-tech-will-spread-across-toyota*

22 *Outputs from NHTSA datafiles. National Highway Safety Traffic Administration, 2018, "Compliance and Effects Modeling System." https://www.nhtsa.gov/corporate-average-fuel-economy/compliance-and-effects-modeling-system*

23 *Reference model year 2016 fleet, from NHTSA datafiles. National Highway Safety Traffic Administration, 2018, "Compliance and Effects Modeling System." https://www.nhtsa.gov/corporate-average-fuel-economy/compliance-and-effects-modeling-system, the agencies' assertion that "[o]nly a few manufacturers produced internal combustion engine vehicles with Atkinson cycle engines in MY 2016" is demonstrably wrong. 83 FR at 43037.*

bias toward forcing most of the automaker compliance technology toward higher cost, non-HCR turbocharging paths. It is indisputable that if Mazda and Toyota have developed a cost-effective technology solution in HCR that meets consumer demands and assists in regulatory compliance, it will be much more broadly deployed. As a result, the regulatory analysis must assess the technology's broader potential adoption toward compliance with the existing/augural 2022-2025 standards – not just in a sensitivity analysis but as a primary technology compliance pathway. As a result, the only reasonable and technically valid assumption is that HCR be allowed for application to all vehicle models' engine redesigns through all the model years of the agencies' compliance modeling analysis.

Furthermore, the claim that shifting the CAFE powertrain technology pathways "requires extensive capital and resources that would be required for manufacturers to shift from other powertrain technology pathways (such as turbocharging and downsizing) to standalone Atkinson cycle engine technology"[24] is not reasonable and does not support the numerous constraints imposed on HCR in the Volpe CAFE model. HCR is one of the most simple and cost-effective advanced engine pathways, and Mazda, one of the clear leaders in the technology, is much smaller in sales volume, number of engine lines, and R&D budget than many of the companies on which the agencies have imposed HCR constraints for non-hybrid engines (including BMW, Daimler, FCA, Ford, General Motors, Honda, VWA).[25] [26]

This indicates that the agencies are imposing a nonobjective constraint on use of HCR technology. Even if this "more capital intensive" logic about switching engine technology pathways were valid, the model would nevertheless have a hardwired bias against allowing HCR, based on other constraints it imposes. Thus, the model already prevents vehicles from switching pathways once a vehicle has been assigned an initial pathway. In the baseline fleet, less than 30% of the 2016 baseline fleet uses some form of advanced engine (turbo, HCR, or advanced cylinder deactivation), and thus is pre-assigned to that pathway. If the other 70% of vehicles were allowed to apply HCR technology, they would not have to switch between engine technologies in most cases, as they have not even started on an advanced engine pathway. Yet the model nevertheless prevents those vehicles from adopting the technology, demonstrating that the model has independent artificial limits applied that bar HCR from being applied to those vehicles. In addition, the notion that HCR technology is exclusive of turbocharging and cylinder deactivation is patently false. As explained below, engines employing the Miller cycle (essentially a turbocharged HCR1 engine) already exist today, and advanced cylinder deactivation has been both modeled and benchmarked on highly efficient, high compression engines.

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[24] *83 Fed. Reg. at 43038*

[25] *Mazda's model year 2016 light-duty vehicle sales were about 458,000, the tenth largest automaker group, based on NHTSA's data.* See datafiles at National Highway Safety Traffic Administration, 2018, "Compliance and Effects Modeling System." https://www.nhtsa.gov/corporate-average-fuel-economy/compliance-and-effects-modeling-system

[26] *Mazda turns to more virtual engineering to cut costs. AutoNews. September 23, 2018. http://www.autonews.com/article/20180923/OEM06/180929908/mazda-virtual-engineering-prototype*

Beyond the invalid restriction on HCR technology, the agencies also unreasonably restrict any improvements from HCR from ongoing auto industry developments. The agencies' second level of HCR, named HCR2, is discussed in the NPRM but dismissed as "entirely speculative."[27] HCR2 refers to a high compression ratio engine (14:1), paired with other changes such as cylinder deactivation, engine friction reduction, and cooled exhaust gas recirculation (EGR), as studied by EPA. Because EPA has access to data on benchmarked Mazda engines (one from Europe, and one from US prototype) applying this technology and achieving higher ratios (compression ratio 14:1)[28], the agencies have artificially excluded a technology they know is applicable in the timeframe of the rulemaking. In addition, none of the additional technologies paired with the higher compression engine are speculative in nature, all of them have been produced in current vehicles and have been separately benchmarked for effectiveness. And additional technical development can be expected for all of these technologies.

Moreover, EPA found that existing engine architectures are already well adapted for this technology, and indeed well adapted for the emerging next level HCR2 package of technologies, since the foundational technologies of gasoline direct injection, increased valve phasing authority, higher compression ratios, and cooled exhaust gas recirculation are already in widespread use.[29] The HCR pathway becomes even more cost-effective when the emerging next level HCR2 technology is included. When the agencies remove their artificial constraints on HCR1 and HCR2 and allow technology improvement in a sensitivity analysis for HCR2, the HCR technology penetration is far greater and the overall fleetwide compliance cost is dramatically lower. Appropriately allowing all HCR technology in the modeling of the proposed standards, based on the agencies' best available data on this technology as described in the Draft TAR, reduces the regulatory compliance with the standards by approximately $144 billion dollars – which is a 28% reduction in fleet wide compliance costs.[30] Related to this, the agencies disingenuously try to suggest that it is too costly for companies to shift from engine pathways like turbocharged downsizing to HCR,[31] while this modeling by the agencies shows massively reduced long-term compliance cost by making the switch. Essentially their own modeling showing the huge cost savings refutes any such rationale.

For the 2016 TAR, EPA rigorously investigated potential improvements in HCR effectiveness by benchmarking a 2014 2.0L Mazda SKYACTIV-G engine, building and validating a simulation

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[27] *83 Fe. Reg. at 43038*

[28] *William Charmley, 2018. Presentation to National Academies of Science Committee on the Assessment of Technologies for Improving Fuel Economy of Light-Duty Vehicles – Phase 3. http://sites.nationalacademies.org/cs/groups/depssite/documents/webpage/deps_188071.pptx*

[29] EPA, 2016 Proposed Determination Technical Support Document at 2-310.

[30] *This is based on CAFE modeling showing "Reference case" costs are $502.1 billion and the "Include HCR2 engines" sensitivity case costs are $357.7 billion. See PRIA Table 13-8 (page 1546). The fleet compliance technology cost impact and percent cost reduction with allowing HCR in the CO_2 modeling are even larger, per PRIA Table 13-9. EPA and NHTSA. Preliminary Regulatory Impact Assessment: The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021–2026 Passenger Cars and Light Trucks*

[31] *83 Fed. Reg. at 43038. Shifting the CAFE powertrain technology pathways "requires extensive capital and resources that would be required for manufacturers to shift from other powertrain technology pathways (such as turbocharging and downsizing) to standalone Atkinson cycle engine technology"*

using data related to performance and combustion processes.[32] The agency found additional efficiency improvements were possible through the application of cooled EGR, an increased compression ratio, and cylinder deactivation.[33] In a peer-reviewed paper published by SAE International (2016), EPA found the enhanced Atkinson Cycle engine (HCR2), to be a "promising alternative engineering path."[34] As noted above, in the 2017 Final Determination, EPA argued that the building blocks necessary to operate an engine in Atkinson mode were present in the MY 2016 fleet, and thus that the technology is commercially viable with ample lead time to more broadly incorporate Atkinson Cycle engines, enhanced by the rest of the HCR2 package of technologies, into the fleet.[35] Such technologies included gasoline direct injection (GDI), increased valve phasing authority, higher compression ratios, and cooled EGR.[36] As a result, EPA correctly observed that there was sufficient lead time to adopt the technology before MY 2022 and that it could be incorporated without requiring major vehicle redesigns.[37]

In response to comments to the TAR, in its Proposed Determination, EPA thoroughly responded to concerns over knock limitations and fuel octane for HCR2, explaining its consideration and evaluation of those issues and how EPA had taken the issues into account in both its modeling, engine validation testing, and component cost estimation.[38] To address comments on lack of physical tests from an engine with all the elements of HCR2, EPA explained that:

> "EPA provided physical engine dynamometer test results using a combination of Atkinson Cycle and cooled EGR and results from engine testing conducted using cooled EGR and Atkinson Cycle with physical deactivation of two out of four cylinders. Results were presented in TSD Chapter 2.3.4.1.8.1 of the Proposed Determination and showed that effectiveness used within the Lumped Parameter Model for this combination of technologies was conservative relative to engine dynamometer test data. Data with cylinder deactivation was also compared with published data from Mazda for one of their developmental engines using cylinder deactivation."[39]

EPA further explained:

> "Mazda presented data at the 2015 Vienna Motor Symposium from a SKYACTIV-G engine with a cylinder deactivation system at an advanced stage of development. The engine demonstrated effectiveness comparable to EPA estimates for applying cylinder

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32 *EPA, NHTSA, CARB. Draft Technical Assessment Report: Midterm Evaluation of Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards for Model Years 2022-2025 at 5-280.*

33 *Id. at 5-282.*

34 *Id.*

35 *EPA, 2017. Final determination on the appropriateness of the Model Year 2022-2025 Light-duty Vehicle Greenhouse Gas emissions standards under the midterm evaluation at 23.*

36 *Id.*

37 *Id.*

38 *EPA, 2016. 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, section 2.3.4.1.8*

39 *EPA, 2017. 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. P. 52*

> deactivation to ATK2 and comparable to EPA engine dynamometer testing of the SKYACTIV-G with 2 cylinders disabled. Mazda has used cooled EGR with previous production applications of their SKYACTIV-G engine, currently uses cooled EGR in the SKYACTIV Turbo engine in the 2017 Mazda CX9, and cooled EGR is currently used by Toyota and Hyundai in Atkinson Cycle engines for both hybrid electric vehicle (HEV) and in non-HEV applications. At the 2017 North American International Auto Show, Toyota announced that the base engine in the redesigned 2018 Toyota Camry would be Toyota's 2.5L I4 Dynamic Force Engine with a peak brake thermal efficiency of 40%. The Toyota 2.5L I4 Dynamic Force Engine combines Atkinson Cycle with cooled EGR and a dual PFI/GDI fuel injection system. In 2016, Toyota's Camry model was the best-selling mid-size passenger car in the U.S. VW has already introduced a 4-cylinder Miller Cycle engine, the EA211 TSI® evo, which combines cylinder deactivation, cooled EGR, early intake valve closing, and turbocharging. Miller Cycle is essentially a boosted version of Atkinson Cycle."[40]

Thus, the agencies' purported concerns in the NPRM over the use and effectiveness of cylinder deactivation in HCR2 engines—unsupported by data—have already been addressed and resolved by EPA's updated engine maps and extensive testing plus the corroboration of these results when compared with data from current development vehicles. Despite the careful benchmarking of improved HCR engines by EPA, HCR2 is dismissed in the 2018 proposal as "entirely speculative." Now, in the 2018 proposal, the agencies argue that EPA's SAE paper referenced in the TAR represented only the "theoretical application of additional technologies [to Atkinson Cycle engines] in combination, like exhaust gas recirculation" and that such an enhanced Atkinson Cycle engine is "entirely speculative, as no production engine as outlined in the EPA SAE paper has even been commercially or even produced as a prototype in a lab setting."[41] This technology advancement is not speculative. Instead, it is based on real-world advancements that have already occurred as well as a logical and predictable advancements that will occur in technology in the near-term.

Additionally, they state that, although "simulations with EPA's HCR2 engine map produce results that approach (and sometimes exceed) diesel powertrain efficiency," they purport that "the engine map has not been validated with hardware and bench data, even on a prototype level (as no such engine exists to test to validate the engine map)."[42] Therefore, the agencies state that they do not include EPA's SAE paper in the NPRM analysis "because there has been no observable physical demonstration of the speculative technology, and many questions remain about its practicability as specified, especially in high load, low engine speed operating conditions."[43] This dismissive statement is contradicted by evidence of record: the higher compression Atkinson engine "was previously available with [cooled exhaust gas recirculation] and a higher compression ratio in Japan and Europe and the application of [cylinder

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[40] *Id. at 52-53*
[41] *83 Fed. Reg. at 43038.*
[42] *83 Fed. Reg. at 43038.*
[43] *Id.*

deactivation] on future applications of the [Mazda] SKYACTIV-G engine has been announced by Mazda. There are also production applications of [cooled exhaust gas recirculation] in current production engines (e.g. Mazda SKYACTIV-G Turbo, VW EA211 TSI evo) which are essentially boosted versions of these advances using engine dynamometer testing".[44] The agencies also state that "many engine experts questioned its technical feasibility and near-term commercial practicability" and that Fiat-Chrysler and the auto lobbying group, the Alliance of Automobile Manufacturers, based on their assertion that performance of the HCR2 engine package has not been validated, there are no physical test results replicating the modeling, and the technology is unlikely to meet consumer needs or be ready for commercial application.[45] The agencies do not cite any further information to support the manufacturers' claims. The agencies also claim that many engine experts questioned its technical feasibility and near term commercial practicality; however, the agencies do not identify any such comments or evidence, or agency analysis of them.[46]

In fact, in the Technical Support Document for EPA's Proposed and 2017 Final Determination, EPA addressed all these concerns brought forth by the Alliance (including the costs and effectiveness impacts of using regular octane fuel instead of premium fuel).[47] It is clear that the agencies are opting to defer technical decisions to industry stakeholders and dismissing the EPA's and other information cited in these comments in to apparently insert a deliberate bias into the model by severely restricting HCR technology for consideration in the their compliance modeling. Or, more precisely, it is clear that NHTSA is deferring to stakeholders, and that EPA has been forced to defer to NHTSA. In the interagency review documents, EPA, the agency with far more laboratory experience, applicable data, and modeling expertise at their disposal, observed:

> "There are Atkinson engine vehicles on the road today (2018 Camry and Corolla with cooled EGR and the 2019 Mazda CX5 and Mazda6 with cylinder deac) that use high geometric compression ratio Atkinson cycle technology that is improved from the first generation, MY2012 vintage "HCR1" technology. While it is true that no production vehicle has both cooled EGR and cylinder deac, as the EPA "HCR2" engine did, nonetheless, these existing engines demonstrate better efficiency than estimated by

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44 Proposed Determination TSD p. 2-309. See also discussion at Final Determination Response to Comment p. 52.

45 *83 Fed. Reg. 83 FR at 43038, fns. 141,142*

46 *Id.*

47 *EPA. 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, pp. 2-299 to 2-307. EPA showed how its "difference" engine maps validly represented performance of the ATK2 [HCR2] packages including on different fuels (pp. 301-02); and that the difference maps submitted in the industry comment "provided no information to compare vintage or application of the actual engine or engines tested, and did not state whether or not testing was conducted", lacking any information on "test and/or analytical methods, assumptions, fuel properties. environment test conditions, how the engine was controlled or how control was modeled, the number of data points gathered to generate the AAM 'difference map' to assure that identical testing and a sufficient fit of data was performed" (p. 301). In addition, EPA showed that concerns about knock due to use of cooled exhaust gas recirculation had been considered and resolved by ignition improvements (p. 302).*

EPA. Therefore, it would be appropriate to continue to use EPA's cooled EGR + deac engine map to represent "HCR2" engines." [48]

The proposal completely disregards EPA's accurate observations. It is thus clear that the agencies have artificially excluded a known technology that is applicable in the timeframe of the rulemaking. With many automakers already deploying the HCR1 technology in 2016, and (as EPA has found) technology that has improved beyond HCR1 in 2018 and 2019, suggesting that HCR technology will not improve belies how technology innovation occurs and its use proliferates across the industry. Further, while the agencies acknowledge that Toyota incorporated naturally-aspirated Atkinson technology into the 2018 Camry (the best-selling passenger car in the U.S.), they minimize the significance thereof, suggesting the specific source of efficiency gains in that vehicle are hard to attribute. The 2018 Camry packages HCR1 with most of the technologies evaluated by EPA in their SAE paper; cooled exhaust gas recirculation (EGR), fast warmup, low friction lubrication, improved cam phasing, engine friction reduction, and improved accessories. An extensive analysis by ICCT demonstrated that the package of technologies on the 2018 Camry exceeded the efficiency gains projected by EPA's OMEGA model – a fact which confirms, rather than undermines, EPA's previous judgments regarding HCR2's efficiency and market-penetration potential.[49] Yet, contrary to both the agencies' prior assessments and to real-world evidence that has emerged since then, the agencies now suggest without data that HCR2 is speculative and its efficiency levels are speculative, and therefore propose to limit both applications thereof and innovations thereto. These HCR technology restrictions are unsupportable by fact or theory.

The 2018 Camry also demonstrates that early problems with low-end torque losses associated with Atkinson cycle engines have been completely solved. Compared to the 2015 2.5L Camry engine, the 2.5L high-compression ratio engine in the 2018 Camry has 14% more horsepower (203 up from 178) and 8% more torque (184 ft-lb up from 170 ft-lb), demonstrating that performance is no longer a concern with high-compression ratio engines.

ICCT evaluated a MY2018 Camry that combines an HCR1 engine with several additional improvements in the areas of oil and engine friction reduction, cam phasing, transmission, steering, accessories, fuel injection, cooled EGR, rolling resistance and aerodynamic drag.[50] This vehicle was tested to determine actual emissions results, and these results were compared

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[48] Docket Entry: E.O. 12866 Review Materials for The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021-2026 Passenger Cars and Light Trucks NPRM, Docket ID EPA-HQ-OAR-2018-0283-0453 (hereinafter "EO12866 Review Materials"), File: "EO_12866_Review_EPA_comments_on_the_NPRM_sent_to_OMB,_June_29,_2018" at 82, https://www.regulations.gov/document?D=EPA-HQ-OAR-2018-0283-0453

[49] *John German "How things work: OMEGA modeling case study based on the 2018 Toyota Camry" February 21, 2018. https://www.theicct.org/publications/how-things-work-omega-modeling-case-study-based-2018-toyota-camry. The agencies state that "Engine 25 may overstate the potential improvement with cylinder deactivation technology for the other vehicle classes. Figure 6-108 below shows the engine 24 BSFC map used for 2016 Draft TAR analysis. … Figure 6-109 shows the incremental difference BSFC and thermal efficiency between IAV engine 24 versus engine 25," PRIA at 303, but fail to explain how this compares to or undercuts the significant evidence discussed above showing the effectiveness of this technology.*

[50] *Id.*

to those projected by EPA's OMEGA model. The results were fully consistent with EPA's projections for HCR2 engines, and showed EPA's projections for HCR2 engine might understate their effectiveness. This evaluation of a real world vehicle that comes close to meeting all of the elements of an HCR2 engine makes it clear that HCR2 engines are far from a speculative technology.

The agencies fail to recognize that the full extent of Toyota Camry 2018 improvements included HCR1, with a package with cooled exhaust gas recirculation (EGR), fast warmup, low friction lubrication, improved cam phasing, engine friction reduction, and improved accessories.[51] Our analysis indicates that the available technologies including HCR exceed the agencies' efficiency.[52] The real world evidence to date of the ability of HCR engines to make significant progress towards production of HCR2 technology shows that the agencies' refusal to allow for any future deployment of this technology in their primary analysis of the augural and adopted 2025 scenarios[53] is technically invalid. Based on the interagency dialogue between EPA and NHTSA, it is clear that EPA's expert engineers also suggest including HCR2 broadly in the primary regulatory scenarios:

> "It would be appropriate to include HCR2 engine technology in the primary analysis case as representative of Atkinson engine vehicles on the road today (2018 Camry and Corolla with cooled EGR and the 2019 Mazda CX5 and Mazda6 with cylinder deac) that are improved from the first generation, MY2012 vintage "HCR1" technology. While it is true that no current production vehicle has both cooled EGR and cylinder deac, as the EPA "HCR2" engine did, nonetheless, these existing engines demonstrate similar efficiency"[54]

The agencies also point to the complexity of modeling or projecting the overall efficiency of a package of technologies involving several components, such as HCR2, and note that the MY 2018 Camry showed improved efficiency due in part to improved accessory loads or reduced parasitic losses from accessory systems (IACC).[55] However this complexity issue is common to all of the technology packages included in either OMEGA or CAFE modeling. It is neither a new issue nor an issue that precludes making reasonable engineering judgments. For example, the agencies purport to have a concern that there is no engine map for an HCR2 production engine to verify efficiency projections. However, the agencies have projected efficiency rates for other technology packages where there is no engine map from a production engine. *See* 83 FR at 43308, 39 (discussing advanced cylinder deactivation, considered an "emerging" technology, and stating that "Some preproduction 8-cylinder OHV prototype vehicles were briefly evaluated for this analysis, but no production versions of the technology have been studied. … Since no engine map was available at the time of the NPRM analysis, ADEAC was estimated to improve a basic engine with VVL, VVT, SGDI, and DEAC by three percent (for engines with more than 4

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[51] Id.

[52] *Id.*

[53] *See PRIA p. 302*

[54] *"EO_12866_Review_EPA_comments_on_NPRM_and_Preliminary_RIA_sent_to_OMB,_July_26,_2018". https://www.regulations.gov/document?D=EPA-HQ-OAR-2018-0283-0453. Page 1075.*

[55] *83 FR at 43038.*

cylinders).") That is the purpose of full vehicle simulation modeling, as done by industry and regulatory engineers alike – to project the efficiency impact when several different parts of the vehicle are simultaneously upgraded. In this case, the efficiency gains demonstrated for the 2018 Camry far exceeded any gains allowed for just IACC.

In this case, real world fact checking is also available by comparing the test results from the MY 2018 Camry and the modeled results for HCR2 from the OMEGA model. This comparison supports the validity of the efficiency projection for HCR2, and, if anything, tends to show the projected efficiency is likely underestimated, not overestimated.[56] In sum, in the NPRM, the agencies paint naturally-aspirated HCR2 as unproven with unacceptable performance tradeoffs and uncertain efficiency benefits. But the agencies improperly, and without data, dismiss the facts presented in the TAR and Final Determination, as described above, and the implications of the 2018 Camry improvements and rapid increases in HCR market share. All of these demonstrate that the technically valid approach is for the agencies to restore the availability of HCR2 and allow its use across vehicle models by model years 2025 in the regulatory compliance modeling.

2. Cylinder deactivation

The agencies have artificially and invalidly restricted the deployment of cylinder deactivation technology in the NPRM analysis. The unique structure of NHTSA's technology pathways (discussed in detail below) seems to inexplicably, and without technical basis, disallow the use of deactivation technology on turbocharging and HCR paths. In fact, the projected application of cylinder deactivation (including advanced cylinder deactivation) for the augural standards actually decreases from 10% in the 2016 baseline fleet[57] to 8% in the 2025 fleet.[58] This is just a third of NHTSA's projection of 23% in the Draft TAR. This is not a reasonable result for such an accessible, attractive, and evidently cost-effective of a technology that is already being deployed in 10% of 2016 vehicles. Also, without major changes in the technology input assumptions, this suggests the agencies have made significant technology modeling decisions in the technology pathway modeling that are obscured from public view or from agency discussion. There is, however, no technical reason for the agencies to disallow the use of cylinder deactivation more widely in its technology pathways.

Contrary to the agencies' constrained deployment of cylinder deactivation technology, the evident real-world trends shown in the agencies' own data indicate how attractive and prolific this technology is. Cylinder deactivation is already applied on 1.7 million (or about 10%) of all

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[56] *Id. And see John German "How things work: OMEGA modeling case study based on the 2018 Toyota Camry" February 21, 2018. https://www.theicct.org/publications/how-things-work-omega-modeling-case-study-based-2018-toyota-camry.*

[57] Reference model year 2016 fleet, from NHTSA datafiles. National Highway Safety Traffic Administration, 2018, "Compliance and Effects Modeling System." https://www.nhtsa.gov/corporate-average-fuel-economy/compliance-and-effects-modeling-system

[58] *Output files from NHTSA datafiles. National Highway Safety Traffic Administration, 2018, "Compliance and Effects Modeling System." https://www.nhtsa.gov/corporate-average-fuel-economy/compliance-and-effects-modeling-system*

the baseline model year 2016 vehicles.[59] Applications include cars, SUVs, and pickups, including high-performance versions, by a variety of major automakers (such as Honda Accord, Pilot, and Odyssey; Chevrolet Camaro and Silverado; Dodge Charger and Challenger).[60] These applications combine cylinder deactivation with many advanced valvetrain and direct injection technologies.[61] Some existing baseline combinations include turbocharging and cylinder deactivation, including by multiple General Motors and Volkswagen models.[62] This demonstrates that the technology is viable in the marketplace and many automakers have found it to be highly cost-effective, even with model year 2016 standards, which are far less stringent than the adopted EPA 2025 standards and the Augural NHTSA 2025 standards. Furthermore, in its work to update its vehicle simulation database, EPA benchmarked and characterized continuous cylinder deactivation (termed ADEAC in the NPRM analysis) on an SUV and a 4-cylinder sedan, demonstrating its effectiveness as a viable technology.[63]

The real-world applications stand contrary to the artificial limitations in the agencies' model. For example, as the agencies point out, as of 2013, Volkswagen had introduced turbocharging with active cylinder management in Europe[64] on an in-line 4-cylinder engine and can deactivate two cylinders via cam-shifting under light load conditions. Because the proposal fails to provide appropriate description of why and how it restricts such viable technology combinations in its subjective construction of pathways, we cannot determine if this is an error in NHTSA's unique technology pathways or a technically false assumption. Whichever of these is the case, the agency restrictions on the use of cylinder deactivation with the other engine technologies are invalid. Automakers certainly have the capability to apply cylinder deactivation together with more of the various other powertrain technology combinations.

With respect to HCR2 technology, the agencies state that there are concerns that "noise, vibration and harshness (i.e., consumer acceptance issues) could limit the operation of cylinder deactivation on non-pick-up trucks."[65] This fails to hold up to the real-world application of cylinder deactivation in a wide variety of non-pickup applications, including SUVs. Again, the agencies own model year 2016 dataset makes it clear that cylinder deactivation is many pickups (by FCA and General Motors), but also on many SUV models (by FCA, Honda, General Motors), and cars (by FCA, Honda, General Motors, and Volkswagen group). Based on the dozens of models spanning different brands and vehicle classes, these issues have been readily addressed. In addition EPA also simulated performance of DEAC as part of a package

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59 *Reference model year 2016 fleet, from NHTSA datafiles. National Highway Safety Traffic Administration, 2018, "Compliance and Effects Modeling System." https://www.nhtsa.gov/corporate-average-fuel-economy/compliance-and-effects-modeling-system*

60 *Id.*

61 *Id.*

62 *Id.*

63 *EPA, 2018. Benchmarking and Characterization of a Full Continuous Cylinder Deactivation System. Presented at the SAE World Congress, April 10-12, 2018. Retrieved from https://www.regulations.gov/document?D=EPA-HQ-OAR-2018-0283-0029*

64 *Volkswagen. 2015. http://www.volkswagen.co.uk/technology/petrol/active-cylinder-technology-act, last accessed January 19, 2018.*

65 *PRIA at 303*

with a higher compression (14:1 rather than 13:1) Atkinson engine. These simulations included kinetic knock modeling and calibration of the simulation to knock induction comparable to the original engine configuration for both Tier 2 and LEV III certification fuel.[66] The proposal fails to acknowledge, much less address, this existing ample record of how concerns regarding engine knocking have been identified and resolved.

The technically valid approach is to allow cylinder deactivation, including advanced cylinder deactivation with higher effectiveness, on all vehicle models by model years 2025 in the agencies' compliance modeling analysis, including turbocharging and HCR pathways. Only by allowing all the valid technology permutations can the agencies allow their CAFE model to project cost-effective real-world technology combinations. If they do not remove these constraints, the agencies would be assuring that their model falsely selects less cost-effective technical approaches in their future-year fleet modeling.

3. Turbocharging and cooled exhaust gas recirculation

An additional area that the agencies are incorrectly constraining technology in the NPRM is advanced turbocharging. Automakers and suppliers have rapidly innovated and implemented turbocharging technologies, including underlying components of direct injection and cooled exhaust gas recirculation, since the original 2012 rulemaking. In reference model year 2016 there were approximately 3.3 million vehicle new vehicle sales with turbocharging, constituting about 21% of total new sales in that year. Nearly every major automaker utilizes turbocharging technology, including BMW, Daimler, Fiat-Chrysler, Ford, General Motors, Honda, Hyundai-Kia, JLR, Mazda, Nissan, Subaru, Toyota, Volkswagen, and Volvo.[67]

As the agencies pointed out in the 2016 draft TAR, many auto manufacturers that have launched third- or fourth-generation GDI engines and turbocharged GDI engines are now in volume production at 21- to 25-bar brake mean effective pressure (BMEP).[68] The agencies address these improvements by separately modeling base 18-bar turbochargers (Turbo1) and 22-bar and higher turbochargers (Turbo2). The model also allows the addition of cooled exhaust gas circulation (CEGR1) to Turbo2 engines, although not to Turbo1 engines or naturally aspirated engines. The limitation on naturally aspirated engines is contrary to the real-world -

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[66] *Draft TAR at 5-281, TSD at p. 2-294, 2-302 TSD p. 2-298-299. EPA compensated for the lack of validation of the kinetic knock model by engine displacements to reflect a reduction in vehicle BMEP. This accounted for the potential impact on performance due to knock protection measures used with regular grade fuel. EPA made adjustments to the ignition system in its dynamometer testing to prevent knocking when cooled EGR technology is used in the HCR2 package*

[67] *Reference model year 2016 fleet, from NHTSA datafiles. National Highway Safety Traffic Administration, 2018, "Compliance and Effects Modeling System." https://www.nhtsa.gov/corporate-average-fuel-economy/compliance-and-effects-modeling-system*

[68] *Environmental Protection Agency, National Highway Traffic Safety Administration, California Air Resources Board, July 2016, Draft Technical Assessment Report, https://www.epa.gov/regulations-emissions-vehicles-and-engines/midterm-evaluation-light-duty-vehicle-greenhouse-gas#TAR at 5-23*

even the agencies' baseline dataset shows CEGR in model year 2016 applied to naturally aspirated engines by Fiat-Chrysler, Subaru, Nissan, and Mazda.[69]

Nevertheless, outside of the baseline fleet the agencies link CEGR to Turbo2 in their compliance modeling. And even this application is modeled incorrectly. The agencies find that "Turbo Charging with Cooled Exhaust Gas Recirculation (CEGR1) improves the knock resistance of Turbo2 engines by mixing cooled inert exhaust gases into the engine's air intake. That allows greater boost levels, more optimal spark timing for improved fuel economy, and performance and greater engine downsizing for lower pumping losses. CEGR1 technology is used in only a few vehicles in the MY 2016 fleet, and many of these vehicles include high performance utility either for towing or acceleration." [70]

Based on our scrutiny of the various agency proposal datasets, the agencies have analyzed their turbocharging technology steps in a way that is either a straightforward error or an unsubstantiated constraint. Notwithstanding the agencies' description above that CEGR1 allows "improved fuel economy" and "greater engine downsizing", the agencies modeled the step from Turbo2 to cooled EGR (CEGR1) as having a 0% effectiveness benefit, despite CEGR1 having an additional technical cost of about $359 per vehicle in 2025, which is clearly seen in the input files and the output files of the CAFE model.[71] This is both contrary to the agencies' own description and clearly erroneous, as manufacturers are adopting CEGR not just on Turbo2 engines, but also Turbo1 and HCR naturally aspirated engines.

In the real-world, automakers are adding CEGR technology to turbocharging (Turbo1 and Turbo2), and they are also deploying it on non-turbocharged engines, because it clearly has a significant non-zero benefit; otherwise they would not deploy it. If the agencies do not correct and explain this, they will be retaining an obvious nonsensical error. The most obvious and likely corrections are (1) include realistic effectiveness values for CEGR based on their real-world tested vehicle and simulation data, (2) appropriately allow CEGR be deployed in all other engine technology pathways at various stages (rather than only after Turbo2). To illustrate the extent to which CEGR1 is improperly modeled (and how the model itself fails its primary function of optimizing technology selection), *removing* CEGR1 *reduces* the 2025 average per-vehicle technology costs by approximately $116.[72] In 2025 If the CAFE model properly ranked and chose technology by cost-effectiveness, then removing a technology choice would lead to an increase in cost, not the decrease found here.

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69 *Reference model year 2016 fleet, from NHTSA datafiles. National Highway Safety Traffic Administration, 2018, "Compliance and Effects Modeling System." https://www.nhtsa.gov/corporate-average-fuel-economy/compliance-and-effects-modeling-system*

70 *From NHTSA input and output datafiles. National Highway Safety Traffic Administration, 2018, "Compliance and Effects Modeling System." https://www.nhtsa.gov/corporate-average-fuel-economy/compliance-and-effects-modeling-system*

71 *From NHTSA input and output datafiles. National Highway Safety Traffic Administration, 2018, "Compliance and Effects Modeling System." https://www.nhtsa.gov/corporate-average-fuel-economy/compliance-and-effects-modeling-system*

72 *83 Fed. Reg. at 43037*

As discussed in more detail below, this clearly demonstrates three problems with the modeling in the NPRM. The CEGR results demonstrate that: (1) the agencies have failed to appropriately evaluate CEGR effectiveness in accordance with real-world mpg and CO_2 impacts, (2) have failed to vet their inputs against how auto industry leaders have actually implemented the technology, and (3) the CAFE model does not properly select technology based on cost-effectiveness, thereby overestimating compliance costs. Regarding the first issue, the modeling of efficiency synergies by Argonne National Laboratory (ANL), upon which all of the efficiency calculations are based, is clearly wrong or not reflective of the technologies that automakers deploy if it suggests there is no independent benefit from CEGR. As to the second issue, the inputs for the Volpe model have evidently not been vetted for cost-effectiveness, as the model should only implement technologies that offer additional cost-effective benefit (a technology with a cost but with no benefit must logically fail any reasonable cost-effectiveness test).

Another possible issue is that the CAFE model is erroneously summing technologies into packages that have a flawed internal logic without appropriate cost-effectiveness calculations or quality control checks. One description we found that could plausibly be read as attempting to describe the basis for CEGR's zero-effectiveness value is that the agencies indicate reliance on manufacturer confidential business information.[73] This would seem to be the most troubling possible explanation: that the automakers advised the regulators to count CEGR as having high cost and 0% effectiveness, and that the agencies still forced turbocharged vehicles in future years to include CEGR technology anyway, nevertheless attributing the full cost to the rules, and tried not to disclose it. This would certainly help explain the bias in the agencies' analysis that ultimately drove up the vehicle costs so much higher than in the 2016 TAR. The only other viable reason we can see is that the agencies simply accepted poor and irrelevant data from their contractor who supplied the engine map that showed no CEGR benefit, and that was then used in the Autonomie simulation model. We examine the question of the quality of the engine maps used in the Autonomie model further below. Regardless, the agencies have to fix the underlying problems or their analysis will have no credibility.

In other words, through one or more of these factors, the model is failing to optimize for cost-effective compliance—which is its primary purpose. As a result, the compliance costs the model is projecting cannot be relied upon in a rulemaking. Regardless of the combination of the above issues that are in play, it is obvious that corrections are warranted, as is an explanation of how the agencies would create a such a modeling approach and use such unreasonable and unvetted results in its rulemaking.

Having provided no evidence to the contradict their previous analysis in the Draft TAR, the agencies must apply a 3-4% benefit for CEGR1 (beyond a baseline turbocharged engine with variable valve timing and lift) across all vehicle classes. This estimate is based on EPA's more rigorous original technology assessment in the TAR.[74] This is one of many areas in the

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[73] *83 Fed. Reg. at 43037*

[74] *Environmental Protection Agency, National Highway Traffic Safety Administration, California Air Resources Board, July 2016, Draft Technical Assessment Report, https://www.epa.gov/regulations-emissions-vehicles-and-engines/midterm-evaluation-light-duty-vehicle-greenhouse-gas#TAR*

rulemaking where the agencies have failed to support their dismissal of the original EPA analysis and its peer-reviewed, laboratory-benchmarked data. Also, as CEGR is already in production on multiple naturally aspirated engines (as described above, and as reflected in the agencies' own analysis fleet), CEGR1 benefits must be extended beyond turbocharged engines to also be applicable to naturally aspirated engines.[75]

Furthermore, the agencies in the NPRM have ignored entirely the more advanced turbocharging developments that continue to emerge . The agencies reject the deployment of such advanced turbocharging technology, arguing that "[t]urbo engines with very high BMEP have demonstrated limited potential to improve fuel economy due to practical limitations on engine downsizing and tradeoffs with launch performance and drivability. Based on the analysis, and based on CBI, CEGR2 turbo engine technology was not included in the NRPM analysis." [76]

Newer designs use head-integrated, cooled exhaust manifolds and coolant loops that enable 27-bar BMEP with greater benefits, including increased ability to downspeed the engine without pre-ignition and cost savings in the design of the turbocharger turbine housing.[77] In addition electric-boost technology, discussed below, could even achieve 30-bar.[78]

It would be appropriate for the agencies to allow more advanced 27-bar turbocharging with improved cooled exhaust gas recirculation (i.e., Turbo2 with CEGR2). The agencies considered advanced Ricardo vehicle simulation, peer-reviewed the analysis in the agencies' original rulemaking,[79] and conducted advanced benchmarking of turbocharging developments,[80] indicating that 27-bar turbocharging technology will be available in within the timeframe of this proposed rulemaking.

4. Homogeneous charge compression ignition

Homogeneous charge compression ignition (HCCI) has been the holy grail of gasoline engine efficiency for decades, but controlling the timing of ignition of the gasoline requires great engineering precision. Diesel fuel ignites immediately upon injection of fuel, so the ignition timing is controlled by the fuel injection, but for gasoline engines the fuel is pre-mixed and the gasoline ignites as the cylinder temperature rises due to compression.

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75 *However, of course, if the agencies did not fix their unsupportable high-cost-no-benefit CEGR error, or their ability to select technologies only if they are cost-effective, as mentioned above, adding more CEGR to more packages would be ill-advised as it would simply compound the agencies invalid modeling.*

76 *83 Fed. Reg. at 43037*

77 *Environmental Protection Agency, National Highway Traffic Safety Administration, California Air Resources Board, July 2016, Draft Technical Assessment Report, https://www.epa.gov/regulations-emissions-vehicles-and-engines/midterm-evaluation-light-duty-vehicle-greenhouse-gas#TAR at 5-23*

78 *Aaron Isenstadt, John German, Mihai Dorobantu, David Boggs, Tom Watson, October 2016, Downsized, boosted gasoline engines. https://www.theicct.org/publications/downsized-boosted-gasoline-engines*

79 *Ricardo 27-bar*

80 *William Charmley, 2018. Presentation to National Academies of Science Committee on the Assessment of Technologies for Improving Fuel Economy of Light-Duty Vehicles – Phase 3. http://sites.nationalacademies.org/cs/groups/depssite/documents/webpage/deps_188071.pptx and EPA benchmarking. Test Data Packages from Benchmarking. https://www.epa.gov/vehicle-and-fuel-emissions-testing/benchmarking-advanced-low-emission-light-duty-vehicle-technology#test-data*

Mazda solved the ignition timing problem by injecting a tiny amount of fuel directly at a spark plug and coordinating this additional fuel injection with a spark to precisely control the combustion timing and ignite the lean, pre-mixed fuel around it. Mazda calls this process Spark Controlled Compression Ignition (SPCCI), using the branding SKYACTIV-X. Here are key excerpts from Mazda's statement:[81]

- "A proprietary combustion method called Spark Controlled Compression Ignition overcomes two issues that had impeded commercialization of compression ignition gasoline engines: maximizing the zone in which compression ignition is possible and achieving a seamless transition between compression ignition and spark ignition."
- "Compression ignition and a supercharger fitted to improve fuel economy together deliver unprecedented engine response and increase torque 10-30 percent over the current SKYACTIV-G gasoline engine."
- "Compression ignition makes possible a super lean burn that improves engine efficiency up to 20-30 percent over the current SKYACTIV-G, and from 35-45 percent over Mazda's 2008 gasoline engine of the same displacement. SKYACTIV-X even equals or exceeds the latest SKYACTIV-D diesel engine in fuel efficiency."
- As part of the new technology to achieve this vision, the company disclosed plans to introduce a next-generation engine called SKYACTIV-X in 2019. SKYACTIV-X will be the world's first commercial gasoline engine to use compression ignition.

This is an excellent example of how advances in computer aided design, computer simulations, and on-board computer controls are accelerating technology development and enabling technologies that were never possible before. Gasoline compression ignition requires highly accurate simulations of how compression ignition can be controlled and extremely fast computers to be able to accomplish proper control and adjust for each combustion event (at 4800 engine rpm, there are 80 combustion events every second). Mazda recently stated, "95 percent of the time-consuming calibration work on Mazda's next generation of vehicles will be done digitally on a desktop, rather than the traditional way of trial and error on pricey prototypes. It uses desktop modeling for about 75 percent of its development work today, and relied on it for only 25 percent of the work in 2007."[82] Today, this computing power is readily available.

The agencies acknowledge the benefits of HCCI and Mazda's production plans for 2019, but fail to include it in their modeling, even for Mazda. The agencies argue that "HCCI has not been included in simulation and vehicle fleet modeling for past rulemakings and has not been included HCCI in this rulemaking as well; this is primarily due to the fact that manufacturers were not manufacturing HCCI engines at the time of the 2012 rulemaking, and accordingly there was a lack of conclusive and independently verifiable effectiveness, cost, and mass market

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[81] *Mazda Announces Long-Term Vision for Technology Development, 'Sustainable Zoom-Zoom 2030', August 8, 2017. http://www2.mazda.com/en/publicity/release/2017/201708/170808a.html*

[82] *Mazda turns to more virtual engineering to cut costs,* Automotive News, September 13, 2018. http://www.autonews.com/article/20180923/OEM06/180929908/mazda-shifts-from-prototype-to-desktop

implementation data available."[83] Although the agencies are correct that HCCI was not in production in 2012, it will be in model year 2019, and the agencies cannot continue to act as though this production-ready technology remains unavailable within the timeframe of the regulation.

While Mazda is the first to solve the computational problems, enabled by Mazda's commitment to virtual engineering,[84] Mazda is a small company with a much smaller R&D budget than most other manufacturers. Given the large benefits of HCCI and the major competitive advantage it gives Mazda, other manufactures must soon follow. EPA has proven its ability to accurately estimate efficiency and cost for emerging technologies. For example, the agencies developed estimates for ADEAC in the NPRM and the associated modeling even without "conclusive and independently verifiable effectiveness". It is essential for the agencies to develop and model the best possible estimates for HCCI and allow the technology to spread across the fleet. Not doing so would make the agencies negligent in their investigation into the viable available technologies available within the rulemaking timeframe.

5. Miller cycle

Miller Cycle was not evaluated for the 2012 rulemaking. For the midterm evaluation, EPA recognized the direct injection Miller cycle engine as one of the technologies that received a significant update since the 2012 final rule. The agencies described that a "[n]ew generation of turbocharged GDI engine combines direct injection, the ability to operate over a Miller Cycle (boosted Atkinson Cycle) with increased expansion ratio, wide-authority intake camshaft timing, and an optimized combustion process."[85]

As the agencies have observed, Miller Cycle "combine[s] direct injection, a substantial increase in geometric compression ratio relative to other boosted engines, wide authority intake camshaft timing, and variable exhaust camshaft timing, and an optimized combustion process enabling significant reductions in CO_2 as compared to a standard direct injected engine. This is essentially Atkinson Cycle with the addition of a turbocharger boosting system. The addition of a turbocharger improves volumetric efficiency and broadens the areas of high-efficiency operation. The ability to reduce pumping losses over a large area of operation may allow avoidance of the additional cost of higher gear count transmissions. This technology was not considered in the 2012 Final Rulemaking."[86] Then, in the Draft TAR, EPA identified several recent or upcoming production models that used Miller Cycle engine technology, and identified the potential for longer term development of Miller Cycle technology."[87]

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83 *The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021–2026 Passenger Cars and Light Trucks, Preliminary Regulatory Impact Analysis, page 240.*

84 *Mazda turns to more virtual engineering to cut costs. Automotive News, September 23, 2018. http://www.autonews.com/article/20180923/OEM06/180929908/mazda-shifts-from-prototype-to-desktop*

85 *Draft TAR at 5-4,5*

86 *Id. at 5-9*

87 *Id. at 5-15, 28, 31, 34, 41*

However, in the NPRM, these Miller cycle engines (i.e., advanced high compression ratio turbocharged engines) have been inappropriately excluded from the agencies' analysis. The agencies indicated that "[t]hese engines may be considered in the analysis supporting the final rule, but these engine maps were not available in time for the NPRM analysis."[88] Because the agencies have not incorporated the technology in the analytical modeling, they have greater reduced the allowable efficiency packages that are allowed in their future year compliance modeling.[89]

Yet, as the agencies have pointed out, the technology has been in use and the agencies do have access to data and engine maps. Peugeot applied a 24-bar BMEP turbocharged Miller cycle engine in 2014.[90] The MY 2016 Mazda CX-9 2.5L SKYACTIV Turbo engine similarly combines the use of Miller Cycle with cooled EGR.[91] And Volkswagen introduced a Miller Cycle variant that has been accepted in the European marketplace[92] and is now being used in the U.S. (Audi A4 and Volkswagen Tiguan), and EPA has even benchmarked the Volkswagen engine.[93] The agencies' decision to exclude this technology has artificially restricted the cost-effective technology's penetration and contributes to the agencies' exaggerated costs.

While the agencies discuss the Miller cycle engines to some extent in the NPRM and the PRIA, they exclude this technology in their modeling, citing the engine map was not available in time, as noted above. This logic is both unsound and demonstrably false. For another emerging technology (advanced cylinder deactivation), the agencies have used a simulated engine map. In the case of the Miller cycle engine, there is an IAV engine map.[94] But, unlike advanced cylinder deactivation, the agencies have arbitrarily decided not to create a simulated engine map, and to instead exclude Miller cycle from the CAFE model without rational explanation. It is unclear why the agencies decided to restrict the use of the technology when they have engine map data and know the technology is emerging in the real-world.

Moreover, as reported publicly, EPA also has access to Miller cycle engine maps. The agency has accessed the engine map for a 2-liter Volkswagen Miller Cycle engine.[95] Using this data in

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88 *83 Fed. Reg. at 43051, fn. 174*

89 The description of the CAFE model now indicates that Miller Cycle has been removed from the engine technology pathway. Miller Cycle is no longer included at all in the turbocharging path (as it was for NHTSA's CAFE modeling in the TAR). 83 FR at 43169, PRIA at 489, 493.

90 *Sellnau, M. "Advancement of Gasoline Direct Injection Compression Ignition (GDCI) for US 2025 CAFE and Tier 3 Emissions," SAE 2017 High Efficiency IC Engine Symposium. April3, 2017.cEGR*

91 *NHTSA Benchmarking, "Laboratory Testing of a 2016 Mazda CX9 2.5 I4 with a 6 Speed Transmission." DOT HS 812 519.*

92 *Eichler, F., Demmelbauer-Ebner, W., Theobald, J., Stiebels, B., Hoffmeyer, H., Kreft, M. "The New EA211 TSI® evo from Volkswagen." 37. Internationales Wiener Motorensymposium 2016.*

93 *NHTSA Benchmarking, "Laboratory Testing of a 2016 Mazda CX9 2.5 I4 with a 6 Speed Transmission." DOT HS 812 519.*

94 *Engine map 23b High Compression Miller Cycle Engine with Variable Geometry Turbocharger. PRIA. Figure 6-115, p 307-308*

95 *William Charmley, 2018. Presentation to National Academies of Science Committee on the Assessment of Technologies for Improving Fuel Economy of Light-Duty Vehicles – Phase 3. http://sites.nationalacademies.org/cs/groups/depssite/documents/webpage/deps_188071.pptx*

the TAR, EPA estimated that Miller cycle would improve fuel economy by 3% to 5% over an already highly efficient 24-bar turbo engine.[96] And the agencies have benchmarked the MY 2016 Mazda CX-9 2.5L SKYACTIV Turbo engine, which not only includes the use of Miller Cycle, but combines it with cooled EGR.[97] This is another example where the agencies have neglected to include available information that EPA has already assessed and benchmarked in the TAR. The agencies' decision to exclude this technology has artificially restricted the technology penetration and contributes to the agencies' exaggerated costs.

Because the Miller cycle has been proven in applications demonstrating significant efficiency benefits, and because the agencies have at their disposal the relevant data to assess those benefits, the agencies' decision to artificially constrain application of the Miller cycle in the Volpe model is unrealistic and unreasonable. The agencies must include Miller cycle as an option for application on all turbocharging and HCR deployment paths, so it can be correctly incorporated in the compliance modeling in all instances in which it is cost-effective.

6. Electric turbocharging

Like for Miller cycle, the agencies have excluded electric-turbocharging from their analysis of the 2025 standards, indicating "[t]hese engines may be considered in the analysis supporting the final rule, but these engine maps were not available in time for the NPRM analysis."[98] But, as with advanced cylinder deactivation, the agencies have a simulated engine map that could be applied for an electrically boosted engine.[99] These "e-boost" systems comprise a higher voltage electrical system (48 volt) used to provide power to a small electric compressor motor within a turbocharger. This directly boosts the engine and spins up the turbocharger to greatly reduce turbo lag, thereby increasing the ability to downsize and downspeed the engine and also reducing backpressure, thereby providing significant efficiency benefits.[100] The first E-boost system application in production was on the 2017 Audi QS7, although only in Europe.[101] The first production system in the US is on the Mercedes 2019 AMG CLS53.[102] Excluding an existing 2017 technology that will be sold in the US fleet in model year 2019 shows the agencies have failed to thoroughly assess current technologies and have therefore fallen far short of considering the full range of potential deployment of probable 2025 technologies.

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96 *Environmental Protection Agency, National Highway Traffic Safety Administration, California Air Resources Board, July 2016, Draft Technical Assessment Report, https://www.epa.gov/regulations-emissions-vehicles-and-engines/midterm-evaluation-light-duty-vehicle-greenhouse-gas#TAR. See Table 5.64*

97 NHTSA Benchmarking, "Laboratory Testing of a 2016 Mazda CX9 2.5 I4 with a 6 Speed Transmission." DOT HS 812 519.

98 *The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021–2026 Passenger Cars and Light Trucks, 83 Fed. Reg. at 43051, fn. 174*

99 *Engine map 24 High Compression Miller Cycle Engine with Electric. PRIA. Figure 6-116, p 308-309*

100 *BorgWarner (2015). Technologies for enhanced fuel efficiency with engine boosting. Presented at Automotive Megatrends USA 2015, 17 March 2015. Slide 26*

101 *Stuart Birch. "Audi claims first production-boosting on 2017 SQ7," Automotive Engineering, March 6, 2016, http://articles.sae.org/14662/*

102 *The All New 2019 Mercedes-AMG CLS53 Coupe. https://www.mbusa.com/mercedes/future/model/model-2019_Mercedes_AMG_CLS53_Coupe#module=future-gallery&submodule=future-gallery-0&gallery=UNIQUE-GALLERY-IDI0I0*

The only reason provided by the agencies for not allowing deployment of this technology in their modeling is the absence of an engine map, as noted above. However, the simulated engine map could provide insights into the general improvements offered by e-boosting. By choosing to ignore the potential of this production-ready technology, while including others (advanced deactivation, e.g.), the agencies have acted arbitrarily. While the agencies have not quantified the efficiency and cost of E-boost systems, ICCT and the suppliers estimated efficiency benefits of 5% at a cost of about $400 for e-boost systems, based on our analysis of efficiency suppliers' developments.[103] he agencies must assess and include e-boost technologies, including all possible effectiveness and cost synergies with both Miller cycle and 48-volt mild hybrid systems, within their compliance modeling. For the agencies to not utilize their own modeling experts (i.e., at EPA), their preferred contractor for this rulemaking (Argonne) or last rulemaking (Ricardo), the supplier network that has developed this technology, or the automakers that have already deployed this technology shows a lack of effort to include this technology in their assessment that is supposed to include all applicable technologies through 2029.

7. Stop-start systems

The 12-volt stop-start system (12VSS) is a rapidly maturing technology, with applications on over 1.95 million, or 12% of, new model year 2016 vehicle sales.[104] Companies that are deploying this technology in some form include BMW, Fiat-Chrysler, Ford, General Motors, Honda, Hyundai-Kia, Jaguar Land Rover, Mercedes, Nissan, Toyota, Volkswagen, and Volvo.[105] The agencies have invalidly reduced the effectiveness of the 12-volt start-stop system. Without acknowledgement or reasonable justification, the agencies have estimated that the CO_2 and fuel consumption of the 12-volt start-stop system for a baseline 2016 vehicle has dropped in benefit from 4.1% in the TAR to 3.1% in the NPRM. When stop-start technology is applied in combination with relatively typical technologies, the agencies are effectively limiting the CO_2 effectiveness benefit of stop-start to approximately 1.0%.[106]

In addition, the agencies are not appropriately including the full regulatory benefit of stop-start technologies due to their off-cycle improvements. At least 1.2 million model year 2015 vehicle sales by BMW, Fiat-Chrysler, Ford, General Motors, Honda, Hyundai-Kia, Jaguar Land Rover, Mercedes, Nissan, Toyota have start-stop technology and received off-cycle credits in the

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[103] *Aaron Isenstadt, John German, Mihai Dorobantu, David Boggs, Tom Watson, October 2016, Downsized, boosted gasoline engines. https://www.theicct.org/publications/downsized-boosted-gasoline-engines*

[104] *Reference model year 2016 fleet, from NHTSA datafiles. National Highway Safety Traffic Administration, 2018, "Compliance and Effects Modeling System." https://www.nhtsa.gov/corporate-average-fuel-economy/compliance-and-effects-modeling-system*

[105] *Id.*

[106] *This is the sale-weighted average across vehicle classes, when CEGR1, AT10L2, EPS, IACC, BISG, LDB, ROLL20, MR4, AERO20 are included with and without stop-start technology. See Table 5 below.* These are based on the datafiles of the agencies at *National Highway Safety Traffic Administration, 2018, "Compliance and Effects Modeling System." https://www.nhtsa.gov/corporate-average-fuel-economy/compliance-and-effects-modeling-system. We cannot determine why the results are effectively reduced from over 12% to more like 1%, but we discuss vehicle modeling issues below.*

existing regulations.[107] These off-cycle credits for idle stop-start technology resulted in an additional 2.5 g/mile for cars and up to 4.4 g/mile for light trucks toward compliance, with similar credits under the CAFE standards – and automakers have been routinely petitioning for more credit.[108,109] However, the agencies have inexplicably and unjustifiably excluded this associated compliance benefit in the modeling for the proposal. The agencies, based on compliance data held by EPA,[110] would readily know precisely the percentage improvements for these start-stop technologies, including both on-cycle and off-cycle. This appears to be another case where the agencies are either intentionally ignoring the full compliance benefits of the technology or simply have ignored the knowledge and expertise of the EPA engineering and compliance staff.

We recommend the agencies report a full listing of all the baseline 2016 vehicle models with stop-start technology, with their test-cycle, and off-cycle improvement in g/mile and percent effectiveness. Not doing so would be hiding relevant data the agencies have readily available to more rigorously assess existing stop-start technologies and their impact for the rulemaking. The agencies must ensure that the regulatory analysis correctly includes these valid test-cycle *and* off-cycle effectiveness values in its compliance assessment for all future-year regulatory scenarios. Not doing so would ignore applicable and available data, and it would also continue to artificially inflate the agencies' technology penetration and cost estimate.

8. Mild hybrid systems

The agencies have not comprehensively assessed mild-hybrid technology effectiveness. The agencies have invalidly reduced the effectiveness of the mild-hybrid systems, both the belt- and crank-integrated starter generator (BISG and CISG) systems. Without reasonable justification, the agencies have estimated that the CO_2 and fuel consumption benefit of BISG compared against 2016 baseline vehicles dropped from 9.5% to 6.1% since the Draft TAR assessment, while the benefit of CISG dropped from 16.1% to 5.8%.[111] When the technology is applied along with technologies included in the modeling for the augural standards, the benefit of BISG dropped from 6.6% to 5.3% and the benefit of CISG from 10.1% to 4.4%.[112] Given the high cost

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[107] *U.S. Environmental Protection Agency, 2017. Greenhouse Gas Emission Standards for Light-Duty Vehicles Manufacturer Performance Report for the 2016 Model Year. Accessed from https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100TGIA.pdf*

[108] *Nic Lutsey and Aaron Isenstadt, 2018. How will off-cycle credits impact U.S. 2025 efficiency standards. https://www.theicct.org/publications/US-2025-off-cycle*

[109] *U.S. Environmental Protection Agency, 2017. Greenhouse Gas Emission Standards for Light-Duty Vehicles Manufacturer Performance Report for the 2016 Model Year. Accessed from https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100TGIA.pdf*

[110] *U.S. Environmental Protection Agency, 2017. Greenhouse Gas Emission Standards for Light-Duty Vehicles Manufacturer Performance Report for the 2016 Model Year. Accessed from https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100TGIA.pdf*

[111] These are based on all the input files of the agencies at *National Highway Safety Traffic Administration, 2018, "Compliance and Effects Modeling System." https://www.nhtsa.gov/corporate-average-fuel-economy/compliance-and-effects-modeling-system. We cannot determine how or why these reductions in effectiveness came about, however, it appears as though this is simply due to shifting to the Autonomie modeling system, on which we present many issues, further below.*

[112] Id.

of the mild hybrid systems and the 33% market penetration projected for the augural case, this drop in efficiency is not only unjustified but has a major impact on the total cost projected in the NPRM for the augural standards.

The agencies have also failed to examine available technology in the marketplace to determine the technology CO_2 and fuel consumption reduction effectiveness. The 2019 RAM fullsize pickup with the V8 engine is offered with a stand-alone belt-integrated starter generator system option. The efficiency benefit for both 2wd and 4wd pickup trucks is 10%[113], much higher than the agencies' estimate of 5.7% versus baseline 2016 pickup trucks in the NPRM and also higher than the 8.1% benefit estimated in the TAR.[114] In addition RAM did not apply engine downsizing with the BISG system on that truck, so there are also significant performance benefits that should be accounted for, meaning that for constant-performance the fuel consumption reduction would be even greater than 10%. The ICCT and supplier technology report on hybrids estimated that that the benefit of mild-hybrid technology, when adjusted for constant performance, is approximately 12.5%, remarkably similar to that actually achieved by the 2019 RAM pickup.[115] This system will be eligible for start-stop off-cycle credits that increase the benefit further.

In addition, the agencies have failed to properly explain or assess the potential for advanced pickup truck credits for mild hybrid and other low-emission technologies that can achieve "game changer" credits. These credits amount to a bonus 10 and 20 g/mile CO_2 credit, based on several provisions. We see no analysis of the cost-effectiveness of these credits; however we do see that the agencies are seeking comment on extending the credits and expanding their use to other vehicle segments.[116] These technology credits amount to poor public policy, as the agencies are giving credit for technologies that are already being deployed to meet the standards, they are scarcely discussed or assessed as to their value or implications for individual companies selling pickups. Expanding these credits, without analysis of their impacts to date or the potential implications truly amounts to poor and unthoughtful public policy. We strongly recommend that the agencies do not expand "game changer" credit program for other vehicle types. As a matter of running a credible regulatory analysis, the agencies must properly assess the program's value and implications on a fleet and individual company basis. They should, at a minimum, include the applicable credits on all the pickups that have stop-start and mild hybrid technology (these are 10 and 20 g/mile in benefit, at no additional technology cost) within the technology packages and pathways in the CAFE and OMEGA modeling. They should also examine whether any non-hybrid pickups might also be eligible for the credits in the 2025 timeframe and present their assessment the public.

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[113] *Eric Junga, Pickups gearing up for huge fuel economy improvements. American Council for an Energy-Efficient Economy. July 19, 2018. https://aceee.org/blog/2018/07/pickups-gearing-huge-fuel-economy*

[114] *The agencies' pickup truck BISG improvement estimates are somewhat less than the sales-weighted benefit for all vehicle classes of 9.5% in the TAR and 6.1% in the NPRM.*

[115] *Aaron Isenstadt, John German, Mihai Dorobantu, David Boggs, Tom Watson, October 2016, Downsized, boosted gasoline engines. https://www.theicct.org/publications/downsized-boosted-gasoline-engines*

[116] *The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021–2026 Passenger Cars and Light Trucks, 83 Fed. Reg. at 83 CFR p 43445.*

We recommend that the agencies re-examine their mild hybrid benefits and revise them accordingly to include an CO_2 effectiveness value of 12.5% – and including off-cycle and game-changing pickup credits in the effectiveness. It is the responsibility of the agencies to include all applicable credits with their technology packages calculations and their projections, including any additional credits that will automatically accrue (e.g., off cycle, game changing pickup credits). This real-world example shows that agencies are not doing their due diligence on emerging technologies in the current marketplace—and also perhaps that automakers are not being forthcoming in describing their available technologies that they are deploying.

9. Full hybrid systems

The agencies also have several flaws in their modeling of full hybrid technology. First, the benefits of level 2 transmission efficiency and TURBO2 over TURBO1 are removed when P2 strong hybrid systems (SHEVP2) are selected on the electrification pathway, and this inappropriately reduces the benefits of P2 hybrids when they use advanced transmission technologies.[117] Although the limited comment period rendered us unable to quantify the specific cost impacts of this error, as the modeling for the augural case forecasts that 22% of the fleet will have SHEVP2 systems, [118] this has major impacts on the overall costs. The agencies do not acknowledge, justify, or substantiate this constraint It could be an error or a deficiency in the Argonne Autonomie modeling system's ability to analyze such systems like the Ricardo and EPA Alpha modeling tools that were previously relied upon in the agencies earlier, more-rigorous analysis.

The agencies' hybrid modeling also has clear deficiencies related to their inappropriate decisions on constraining HCR technology. As discussed above, the constraints on HCR applications on all vehicles, are preventing non-hybrid baseline vehicles from adopting the most cost-effective technologies (like HCR) if they become P2 hybrids. HCR technology is in use on hybrid models by most automakers that are deploying hybrids,[119] and it appears to be a very likely combination by all real-world evidence, yet the agencies' pervasive constraints are disallowing HCR on many hybrids for most automakers. This constrains BMW, Daimler, FCA, Honda, JLR, Subaru, Volvo, and Volkswagen from the likely most cost-effective hybrid-HCR approach (based on the hybrid leaders to date), based on our analysis of the agencies datafiles.

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[117] These are based on all the input files of the agencies at *National Highway Safety Traffic Administration, 2018, "Compliance and Effects Modeling System." https://www.nhtsa.gov/corporate-average-fuel-economy/compliance-and-effects-modeling-system. We cannot determine how or why the agencies chose to model in this way as we only see these results according to the detailed datafiles that are largely obscured from public view.*

[118] The 22% share of 2025 model year vehicles is from output files, from *National Highway Safety Traffic Administration, 2018, "Compliance and Effects Modeling System." https://www.nhtsa.gov/corporate-average-fuel-economy/compliance-and-effects-modeling-system.*

[119] *Hybrid HCR vehicles are in the reference 2016 datafleet for the automakers Ford, General Motors, Hyundai, Kia, Nissan, and Toyota.* These are based on all the input files of the agencies at *National Highway Safety Traffic Administration, 2018, "Compliance and Effects Modeling System." https://www.nhtsa.gov/corporate-average-fuel-economy/compliance-and-effects-modeling-system.*

Additionally, the agencies' modeling is pushing turbocharging on hybrid packages, thus both restricting these packages' effectiveness and increasing their costs. The artificially-imposed turbocharging-hybrid effectively reduces their package effectiveness because HCR-hybrids typically deliver 3-4% greater benefit than Turbo1 or Turbo2.[120] Regarding costs, as identified above, because the agencies' turbochargers have higher cost than HCR and the agency typically are falsely modeling ineffective CEGR with an additional $300 per vehicle despite no benefit (as described above), the agencies hybrid modeling is falsely propping up compliance costs.

10. Transmissions

The above discussion highlights a wide number of inconsistencies, errors, and various issues in assigning effectiveness and modeling deployment of various engine technologies. The agencies also apply flawed inputs with respect to the availability of high-efficiency transmissions. There has been a steady shift from 4- and 5-speed transmissions five years ago toward 6-and-greater speed transmissions through 2016.[121] In the agencies' model year 2016 reference sales database, 2.95 million (i.e., 18%) of new sales have automatic transmissions with 7-10 speeds. Companies in the 2016 reference fleet that have deployed these 7-and-greater speed transmissions include BMW, Daimler, Fiat-Chrysler, Ford, General Motors, Honda, Hyundai-Kia, Mazda, Nissan, Subaru, Toyota, and Volkswagen.[122] Yet, as described below, the agencies' treatment of these transmissions is incomplete and in direct conflict with these real-world developments.

The agencies have failed to properly assess the effectiveness of high-efficiency transmission technologies. The following Table 1 summarizes the efficiency improvements for each transmission from the Volpe model, assessed using the technologies projected to be used by most vehicles for the augural standards:

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[120] These are based on the input files of the agencies at *National Highway Safety Traffic Administration, 2018, "Compliance and Effects Modeling System." https://www.nhtsa.gov/corporate-average-fuel-economy/compliance-and-effects-modeling-system.*

[121] *Environmental Protection Agency. January 2018. The Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends Report. https://www.epa.gov/fuel-economy-trends and Reference 2016 datafile from National Highway Safety Traffic Administration, 2018, "Compliance and Effects Modeling System." https://www.nhtsa.gov/corporate-average-fuel-economy/compliance-and-effects-modeling-system*

[122] *Reference 2016 datafile from National Highway Safety Traffic Administration, 2018, "Compliance and Effects Modeling System." https://www.nhtsa.gov/corporate-average-fuel-economy/compliance-and-effects-modeling-system*

Table 1. Efficiency improvement for given transmission improvements

NPRM Volpe model using highest volume technologies from augural run (CEGR1, EPS, IACC, BISG, LDB, ROLL20, MR4, AERO20)		
Technology	Compared to	MPG benefit (sales weighted average)
AT6	A5	3.6%
AT8	A5	7.5%
AT10	A5	10.3%
AT6L2	A5	12.0%
AT8L2	A5	9.1%
AT10L2	A5	11.5%
DCT8	DCT6	-1.9%

The efficiency improvement for adding additional gears from AT6 to AT8 to AT10 make sense. However, the impact of adding level 2 transmission efficiency technologies[123] varies wildly and produces absurd results. A 6-speed AT6L2 Is modeled as much more efficient (12.0% improvement) than a comparable 8-speed AT8L2 (9.1%) and even slightly more efficient than a comparable 10-speed AT10L2 (11.5%). Plus, the 8-speed dual-clutch automated transmission (DCT8) is modeled as being less efficient than a comparable 6-speed (DCT6). Accordingly, the agencies CAFE model predicts that there are no new cars that adopt DCT technology between 2016 and their estimated compliance for the model year 2025 augural/adopted standards (i.e., they project a 3% market share remains from the 2016 reference fleet through 2025).

The net impact is that the modeling projects there are no efficiency benefits, in fact, a slight efficiency loss, in moving along the transmission pathway from AT6L2 to AT10L2 transmissions, and from DCT6 to DCT8. Despite this, for the augural standards for model year 2025 the Volpe model projects only 0.1% of vehicles will use AT6L2 transmissions (12.0% benefit), but 33.2% will use AT10L2 transmissions (11.5% benefit), despite their higher cost and *negative* incremental value.[124] Additionally, 4.1% use AT8 transmissions without level 2 (7.5% benefit) and 13.4% use AT10 transmissions without level 2 (10.3% benefit). These results strongly suggest there are major problems in the Argonne simulation and/or CAFE fleet modeling that make one of the tools incapable of rigorously modeling advanced transmissions that are in the market today and likely to be common in 2025. The results also suggest that the agencies made hidden assumptions to reduce the technology effectiveness of the high-efficiency level 2 strategy of the transmission, without disclosure or justification. And the results show that the model fails at its sole purpose of projecting cost-effective compliance pathways, as in this case it adds cost but *decreases* efficiency,

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[123] *The exact technologies included in level 2 efficiency improvements are not defined in the NPRM or the PRIA, but likely include some combination of reduced parasitic losses, improved torque converter behavior, shift to neutral during idle, improvements in clutches and brakes, off-axis oil pump, and increased torque converter lock-up area, which are all discussed in the PRIA.*

[124] *From output files from National Highway Safety Traffic Administration, 2018, "Compliance and Effects Modeling System." https://www.nhtsa.gov/corporate-average-fuel-economy/compliance-and-effects-modeling-system*

The agencies have also failed to include the related transmission technologies being deployed for off-cycle credits (that are in addition to the test-cycle improvement). Transmission warm-up technologies are being deployed due to regulatory test-cycle benefits and off-cycle credits by Fiat-Chrysler, Ford, Honda, Hyundai-Kia, and Nissan in model year 2016.[125] These are worth up to 1.5 g/mile for cars and 3.2 g/mile in CO_2 credits (and equivalent converted fuel consumption credits). Even though transmission warm-up strategies are used by 3.7 million new 2016 vehicles – about 23% of new 2016 vehicles[126,127] – the agencies have not included this technology in their assessment of existing GHG and Augural 2025 CAFE standards. To appropriately model the model year 2025 standards, the agencies need to include these credits as applicable for these companies already using the technology, and any other companies that are likely to use them based on existing product plans and cost-effectiveness. This appears to be another of the many cases where the agencies did not include the EPA's engineering expertise or compliance data.[128]

The agencies must transparently show the combined efficiency and cost values of each combination of transmission technology (each gear count, levels 2 and 3, and what the levels include regarding shift logic and gear box efficiency improvement) in a logical cumulative set of steps from an automatic 5-speed, including how high-efficiency gearbox and optimized shifting strategy technologies are included. Otherwise it appears that that the agencies improperly modeled transmission effectiveness and/or restricted applicable and highly cost-effective transmission technologies. In addition, the agencies must use all their existing data on transmission off-cycle credits, and assume that every automaker will deploy the off-cycle technology with the maximum 2016 credit of 1.5 g/mile for cars and 3.2 g/mile in CO_2 credits on all of their 2025 vehicles. Not including known off-cycle technology would apparently amount to negligently ignoring known low-cost compliance technology that are already experiencing very high use in 2016.

11. Mass reduction technologies

The agencies have invalidly restricted the use of lightweighting technology and its likely contribution to future-year industry efficiency improvements and compliance efforts. The agencies have made a dramatic and unjustified shift in the baseline fleet related to mass reduction. From the model year 2015 baseline used in the draft TAR to the 2016 baseline used in the proposal, the agencies have applied an artificial increase in vehicle mass reduction.

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[125] *U.S. Environmental Protection Agency, 2017. Greenhouse Gas Emission Standards for Light-Duty Vehicles Manufacturer Performance Report for the 2016 Model Year. Accessed from https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100TGIA.pdf*

[126] *U.S. Environmental Protection Agency, 2017. Greenhouse Gas Emission Standards for Light-Duty Vehicles Manufacturer Performance Report for the 2016 Model Year. Accessed from https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100TGIA.pdf*

[127] *Nic Lutsey and Aaron Isenstadt, 2018. How will off-cycle credits impact U.S. 2025 efficiency standards. https://www.theicct.org/publications/US-2025-off-cycle*

[128] *U.S. Environmental Protection Agency, 2017. Greenhouse Gas Emission Standards for Light-Duty Vehicles Manufacturer Performance Report for the 2016 Model Year. Accessed from https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100TGIA.pdf*

According to NHTSA's datafiles, the 2015 fleet (Draft TAR) had 26% of vehicles sold with one of the mass reduction packages, whereas the 2016 fleet (NPRM) had 47% of vehicles (i.e., 7.6 million vehicles).[129] The agencies do not acknowledge this change, and do not even attempt to justify it. Moreover, the real-world fleet did not see increases in mass reduction of this magnitude in 2016. To the contrary, it appears that the agencies have applied mass reduction technology to vehicles in the model that did not have mass reduction applied in the real world. This unreasonable change thus fails to reflect real-world outcomes, and renders unavailable mass reduction technologies for these vehicles in the model. And without these technologies available, the model selects less cost-effective technologies instead, and the effect is to drive the modeled compliance costs higher.

In addition, the agencies have also adjusted the glider mass fraction from 75% of total vehicle mass as used in the draft TAR, down to 50% for the NPRM. This has the effect of reducing the effectiveness of mass reduction technology. The agencies state that this change in glider mass fraction is due to "excluding…some interior system components (because of safety considerations)."[130] This implies that the "interior system components" comprise 25% of total vehicle curb weight, which is an unreasonably high number for such systems. Moreover, even if those systems were that heavy, if such components were safety-critical and not open to lightweighting, they would have been a larger concern in all past rulemakings. In fact, the very studies used by the agencies to estimate costs show glider fraction greater than 75%, with numerous safety features considered.[131] The agencies must specifically identify the "safety components" they are referring to, and justify the limitation they have placed on lightweighting in response.

These are dramatic changes that remove technology from potential use in the 2017-2025 analysis, and they are not substantiated with data showing the automakers actually deployed the technology in the real-world or data showing that the glider mass fraction has changed. As to the first problem - compounding the agencies' lack of evidence, the agencies acknowledge the difficulties in assessing actual mass reduction for fuel efficiency purposes, as compared to mass reduction used to improve performance or offset weight of added features.[132] Thus, in order to substantiate the changes made to the baseline fleet mass reduction assignment, the agencies need to show data on how these improvements are evident in the fleet and to quantify and include their realized benefits in the analysis. If an improvement of this magnitude had actually been implemented on-the-ground, it would be evident in fleet level miles-per-gallon and CO_2 emissions (e.g., in EPA's compliance data, *Trends*[133] and *Manufacturer Performance*[134]

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[129] *Input files from National Highway Safety Traffic Administration, 2018, "Compliance and Effects Modeling System." https://www.nhtsa.gov/corporate-average-fuel-economy/compliance-and-effects-modeling-system*

[130] *PRIA at 417*

[131] *PRIA section 6.3.10.1.1.3, at 390*

[132] *Id. at 415*

[133] *Environmental Protection Agency. January 2018. The Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends Report. https://www.epa.gov/fuel-economy-trends*

[134] *U.S. Environmental Protection Agency, 2017. Greenhouse Gas Emission Standards for Light-Duty Vehicles Manufacturer Performance Report for the 2016 Model Year. Accessed from https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100TGIA.pdf*

reports). But, to the contrary, none of the improvements that would be associated with this additional mass reduction were reflected in the model year 2016 fleet.

Another apparent error is that within that baseline fleet, the agencies appear to have estimated that the mass reduction of vehicle curb mass due to lightweighting technology is 2.3% (sales-weighted across models based on their nominal baseline). By placing this technology in the baseline, the agencies are artificially removing the most cost-effective lightweighting from future use, which incorrectly increases the costs of all subsequent mass-reduction in the compliance modeling. Due to the very large cost and technology impact, and the lack of data substantiation by the agencies, the agencies must clearly and precisely share their estimated percent (and absolute pounds) mass reduction amount for each vehicle make and model in the baseline fleet (rather than simply showing binned categories), and their technical justification for each value. To not do so obscures the agencies' new methods and data sources from public view, rendering their lightweighting calculations a black box. We also recommend that the agencies conduct two sensitivity analyses that assume that every baseline make and model has not yet applied ay lightweighting (that is, is setting their baseline to 0% mass reduction), that each has applied only those previous baseline mass reduction levels shown in the from TAR to demonstrate how much the agencies' decision to load up more baseline technology affects the compliance scenarios, as it appears that the agencies may have made an unsupportable and non-rigorous assumption about mass reduction technology across the models.

In the Augural standards, fleet-sales-weighted lightweighting technology increases from 2.3% in the baseline 2016 fleet to 7.5% by 2025, suggesting that the agencies think the fleet would only see a 5% reduction in average vehicle curb mass from 2016 to 2025. The agencies have incorrectly impeded the uptake of lightweighting in their regulatory analysis of the Augural standards. In addition to rendering mass reduction technologies unavailable by burying them in the baseline fleet, the agencies also appear to force unrealistically low deployment of further mass-reduction technology through 2025 by inflating associated costs (costs are discussed further below), and reducing net benefit by slashing the glider mass fraction. Based on our analysis of automaker announcements and the agencies' baseline data file (See Table 2), there are many vehicle makes and models that demonstrate automakers can and are deploying mass reduction at levels from 5%-15% in the 2016-2017 model years across vehicle types, including small performance cars, midsize cars, SUVs, minivans, and pickups.[135] There is no justifiable reason to expect that other models and other manufacturers would fail to also adopt the same or greater levels of cost-effective mass reduction in model years after 2016, instead of the much more limited adoption modeled by the agencies.

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[135] *Aaron Isenstadt and John German (ICCT); Piyush Bubna and Marc Wiseman (Ricardo Strategic Consulting); Umamaheswaran Venkatakrishnan and Lenar Abbasov (SABIC); Pedro Guillen and Nick Moroz (Detroit Materials); Doug Richman (Aluminum Association), Greg Kolwich (FEV). Lightweighting technology development and trends in U.S. passenger vehicles, December 19, 2016. http://www.theicct.org/lightweighting-technology-development-and-trends-us-passenger-vehicles*

Table 2. Sample of vehicle mass reductions

Source	Vehicle model	Model year	Mass reduction (kg)	Mass reduction (%)	Base year
ICCT	Ford F-150	2016	288	14%	2014
	Acura MDX	2017	172	8%	2013
	GM Cadillac CTS	2017	95	5%	2013
	Audi Q7	2016	115	5%	2015
	Chrysler Pacifica	2017	146	7%	2016
	Opel Astra	2016	173	12%	2015
	Chevrolet Malibu	2016	135	9%	2015
	GMC Acadia	2017	318	15%	2016
	Chevrolet Volt	2017	110	6%	2014
	Chevrolet Cruze	2017	103	7%	2015
	Mazda Miata	2016	67	6%	2015
	Chevrolet Equinox	2018	182	10%	2016
	Chevrolet Camaro	2016	177	10%	2015
Agencies	Chevrolet Corvette Chevrolet Malibu Honda Civic Sedan Hyundai Elantra Hyundai Veloster Kia Forte Kia Soul Mazda Mx-5 Miata Nissan Versa Ram Promaster City Toyota Prius C Toyota Yaris	2016	105-160	10%	Varied
	Cadillac CT6 Ford F150 Kia Rio5 Mazda CX-3 Subaru BRZ Volvo XC90	2016	85-165	7.5%	Varied

The agencies' analysis (i.e., that the fleet in 2025 will have a 7.5% mass reduction (or 5% change from 2016 to 2025)) essentially indicates that some mass-reduction technologies will see increased uptake, but that, on average, the industry will not adopt even today's best available technologies, and that there will be minimal innovation in the years between 2016-2025. We recommend that the agencies assess why their analysis is so artificially conservative in 2025 compared even to the leading lightweighting designs in the 2016-2017 fleet. Specifically, the agencies must either correct their technology and cost analysis to reflect the continued developments, or explain why automakers have chosen to deploy lightweighting in successful products in 2016-2017 if they are not profitable or effective.

Other demonstrations of how artificially and unreasonably restrictive the agencies are on their mass reduction assessment come from statements by the automakers that suggest that 10-15%

and greater mass-reduction are squarely part of their plans. Ford indicated that by 2020 it would see the full implementation of known technology, including weight reduction of 250-750 lbs on its vehicles.[136] This level of lightweighting technology would roughly amount to 10% weight reduction, likely a lower percentage for smaller vehicles and higher percentage for larger vehicles. Toyota aims to reduce vehicle weight by 20% with its Toyota New Global Architecture that was first introduced in 2015 and then will be phased in through its vehicles through the first half of the 2020s.[137] General Motors aims to shed 500 lbs (or about 10%) by 2016, and then as much as 1000 lbs (or 20%), from its trucks in the early 2020s.[138] Mazda aims to reduce each model by 220 lb over 2011-2015 and another 220 lb from 2016 on.[139] These company plans are still underway. From model year 2010 to model year 2016, the average new light-duty vehicle fleet average weight has remained virtually unchanged at about 4,000 lbs.[140] As a result, these mass-reduction efforts are still ongoing and demonstrate that there is much more technology potential that goes well beyond what the agencies are projecting for 2025 mass reduction to comply with the Augural standards.

Beyond making assumptions that largely fail to recognize these ongoing real-world mass-reduction technology developments by companies, it appears clear that the agencies have invalidly nullified the most relevant detailed engineering studies on mass-reduction technology, demonstrating that potential mass reduction technology goes beyond the 10-15% mass-reduction that is discussed above. Peer-reviewed studies by EDAG, FEV, Ford, and Lotus Engineering use state-of-the-art engineering teardown analysis and holistic vehicle safety simulation analysis to assess the technology potential and associated cost for mass reduction. These studies demonstrate that at least 20% mass reduction is available for adoption across vehicle classes by 2025.[141] Much of this reference literature was based on California Air Resources Board staff analysis performed in conjunction with the federal agencies, so the

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[136] *Matthew J. Zaluzec. April 20, 2015. Ford: Go Further. https://www.engr.uky.edu/sites/default/files/ISM/Keynote1-MattZaluzec-Ford-NCMS-Talk.pdf*

[137] *Autonews (2013). Toyota expects weight savings, mpg gains: R&D execs extol technology coming in 2015. http://www.autonews.com/article/20131125/OEM01/311259956/toyota-expects-weight-savings-mpg-gains*

[138] *Levine, M. (2010). Report: Pickup Truck Makers to Reduce Weight to Meet New Fuel Economy Targets. http://news.pickuptrucks.com/2010/12/report-pickup-truck-makers-work-to-reduce-weight-to-meet-new-fuel-economy-targets.html*

[139] *Mazda Sustainability Report 2011. http://www2.mazda.com/en/csr/download/pdf/2011/2011_s_all.pdf*

[140] *Environmental Protection Agency. The Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends Report. https://www.epa.gov/fuel-economy-trends.*

[141] *EDAG (2011) Future Steel Vehicle. http://www.worldautosteel.org/projects/future-steel-vehicle/phase-2-results/ Prepared for WorldAutoSteel; FEV (2012) Light-Duty Vehicle Mass Reduction and Cost Analysis — Midsize Crossover Utility Vehicle. Prepared for US Environmental Protection Agency. EPA-420-R-12-026. http://www.epa.gov/otaq/climate/documents/420r12026.pdf; Lotus Engineering (2012) Evaluating the Structure and Crashworthiness of a 2020 Model-Year, Mass-Reduced Crossover Vehicle Using FEA Modeling. Prepared for California Air Resources Board. http://www.arb.ca.gov/msprog/levprog/levIII/final_arb_phase2_report-compressed.pdf; Singh, H. (2012). Mass Reduction for Light-Duty Vehicles for Model Years 2017-2025. Prepared for National Highway Traffic Safety Administration. Report No. DOT HS 811 666. ftp://ftp.nhtsa.dot.gov/CAFE/2017-25_Final/811666.pdf (accessed in 2012); Geck, P. J. Goff, R. Sohmshetty, K. Laurin, G. Prater, V. Furman, 2007. IMPACT Phase II – Study to Remove 25% of the Weight from a Pick-up Truck. Society of Automotive Engineers. 2007-01-1727 https://www.sae.org/publications/technical-papers/content/2007-01-1727/*

federal agencies are well aware of these studies. As discussed below, the agencies also reinterpreted the results of the main study relied upon in the TAR in order to inflate costs.[142] Thus, it is troubling that the NPRM authors have chosen to disregard and distort analysis that is clearly directly applicable, and this is indicative that the technical assessment by the agencies has a clear technical bias towards reducing CAFE and GHG standards. Excluding these studies amounts to intentionally disregarding the most pertinent and rigorous engineering studies that are applicable to the rulemaking timeframe.

The agencies must revise their treatment of mass reduction. They must adjust their technology inputs based on the most recent data,[143] primarily to increase the maximum available mass reduction potential levels to include up to 20% and 25% mass reduction. A more reasonable result from the compliance analysis would indicate that the auto industry will cost-effectively deploy at least 15% vehicle curb mass reduction in the 2025 timeframe at near zero net cost (and consistently less than $500). The only vehicle class where such high mass reduction appears less likely is smaller cars,[144] where there is typically lower amounts of mass reduction of less than 10%; therefore constraints at approximately 7.5%, as done in the TAR, appears to be warranted for small cars. Updating their cost estimates to be lower would reflect the best available data and actual industry practices to incorporate all the available and emerging mass-reduction technologies.

The agencies must also re-adopt the TAR methodology in which glider mass is assumed to be 75% of vehicle mass, or provide detailed justification and evidence supporting the new value of 50%. The agencies must provide a detailed and justified explanation of all mass reduction technologies that they have deemed to already have been applied to the model year 2016 analysis fleet. Because of these types of changes that are opaquely buried in the agencies' datafiles and unexplained, we believe the agencies have to reissue a new regulatory analysis and allow an additional comment period for review of their methods and analysis.

12. Aerodynamics

The agencies appear to have failed to appropriately and comprehensively consider all the applicable aerodynamic technologies that are being deployed by automakers. This is the case for both off-cycle credit and test-cycle aerodynamic technology. As a result of these changes, the agencies have artificially increased the modeled compliance costs and decreased the effectiveness of available aerodynamic drag reduction technology available as compared to the TAR.[145]

Aerodynamic technology including the use of grill shutters are being deployed for regulatory off-cycle credits by BMW, Fiat-Chrysler, Ford, General Motors, Hyundai-Kia, Jaguar Land Rover,

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[142] *Compare Figure 6-160 and Table 6-37 in the NPRM with Figure 5.141 and Table 5.175 of the Draft TAR, both of which are based on the same study of a MY2011 Honda Accord.*

[143] *Ibid.*

[144] *Aluminum Association.* https://www.drivealuminum.org/wp-content/uploads/2018/08/Mass-Reduction-Chart.pdf

[145] *PRIA section 6.3.10.1.2.1.1.8 and 6.3.10.1.2.1.1.10*

Nissan, Subaru, and Toyota in model year 2016.[146] These are worth up to 0.6 g/mile for cars and 1.0 g/mile in CO_2 credits (and equivalent converted fuel consumption credits). In the 2016 fleet they are used by 3.2 million vehicles or about 20% of new 2016 vehicles,[147] demonstrating that this cost-effective technology will be more broadly deployed post-2016. To appropriately model the Augural standards, the agencies would need to include the increasing use of the aerodynamic off-cycle technology credits as applicable across all companies through 2025. This means giving additional credits in future years for the likely use of grill shutters and any other off-cycle aerodynamic technologies. This appears to be another case where the agencies did not include the EPA's engineering expertise or compliance data, who would be able to better advise based on their certification data from the off-cycle program.[148] As discussed above, this is part of a broader issue, where the agencies are failing to acknowledge a clear and growing trend for automaker applying for and getting approvals for off-cycle technology that is lower cost than the test-cycle technologies the agencies are modeling (these aerodynamic off-cycle credits are approximately 2 g/mile out of 15 g/mile of expected off-cycle credit use by model year 2025).

In addition, the agencies make a different type of error in the treatment of aerodynamic technology in the reference model year 2016 data fleet. The agencies have artificially limited the availability of aerodynamic technologies in the CAFE model in future years by making a very significant and unjustified shift in the model year 2016 baseline fleet.[149] From the model year 2015 baseline to the 2016 baseline, the agencies have deemed approximately three times as many vehicles to have pre-existing aerodynamic improvements as they did in the TAR. The TAR's 2015 fleet had about 8% vehicles sold with one of the aerodynamic packages, whereas the NPRM's 2016 fleet had 53%.

This is a dramatic change that removes technology from potential use in the 2017-2025 analysis, and it is not substantiated with data to show that the automakers deployed the technology. The agencies justify this change by introducing new, intermediate aerodynamic improvement steps, which redistributes the baseline fleet into more advanced aerodynamic levels without observing or verifying real-world aerodynamic improvements. To substantiate this change, agencies need to show data on how these improvements are evident in the fleet and delivering benefits. If an improvement of this magnitude were true, it would be evident in fleet

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146 *U.S. Environmental Protection Agency, 2017. Greenhouse Gas Emission Standards for Light-Duty Vehicles Manufacturer Performance Report for the 2016 Model Year. Accessed from https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100TGIA.pdf*

147 *Input file with reference model year 2016 vehicle fleet from National Highway Safety Traffic Administration, 2018, "Compliance and Effects Modeling System." https://www.nhtsa.gov/corporate-average-fuel-economy/compliance-and-effects-modeling-system*

148 *U.S. Environmental Protection Agency, 2017. Greenhouse Gas Emission Standards for Light-Duty Vehicles Manufacturer Performance Report for the 2016 Model Year. Accessed from https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100TGIA.pdf*

149 *Input file with reference model year 2016 vehicle fleet from National Highway Safety Traffic Administration, 2018, "Compliance and Effects Modeling System." https://www.nhtsa.gov/corporate-average-fuel-economy/compliance-and-effects-modeling-system*

level miles-per-gallon and CO_2 levels (e.g., in EPA's *Trends*[150] and *Manufacturer Performance*[151] reports). But, to the contrary, none of the quantifiable mpg or CO_2 benefits that would be associated with these additional aerodynamic improvements were reflected in any real-world evidence in the model year 2016 fleet. As with mass reduction, this seems to be a case of the agencies artificially burying efficiency technology in the baseline, rendering it unusable in the post model year 2016 compliance scenarios.

Due to the very large cost and technology impact, and the lack of data substantiation by the agencies, the agencies must clearly and precisely share their absolute road load coefficients (i.e., the basis for any aerodynamic calculation) and exact estimated percent improvement (rather than binned percentage categories) for each vehicle make and model in the baseline and future modeled fleet, and their technical justification for each value. To not do so would obscure the agencies' methods. The agencies must also conduct two sensitivity analysis cases that assume that every baseline make and model is set to 0% aerodynamic improvement and set to the previous baseline aerodynamic levels (i.e., from TAR) to demonstrate how much the agencies' decision to load up more baseline technology affects the compliance scenarios, as it appears that the agencies may have made a unsupportable and non-rigorous assumption about aerodynamic technology across the models. Because of these types of changes that are opaquely buried in the agencies' datafiles and unexplained, we believe the agencies have to reissue a new regulatory analysis and allow an additional comment period for review of their methods and analysis.

13. Rolling Resistance

Similarly, the agencies have made a dramatic and unjustified shift in the baseline fleet related to tire rolling resistance. From the model year 2015 baseline to the 2016 baseline, the agencies have introduced a massive increase in tire rolling resistance improvements. According to NHTSA's datafiles, the 2015 fleet had 0% vehicles sold with one of the rolling resistance packages, whereas the 2016 fleet had 46% (i.e., more than 7 million vehicles).[152] Nearly 20% of vehicles now have a 10% reduction in rolling resistance, and more than 26% have a 20% reduction in rolling resistance.[153] This is a dramatic change that removes technology from potential use in the 2017-2025 analysis, and it is not substantiated with data to show that the automakers deployed the technology. To substantiate this, agencies need to show data on how these improvements are evident in the fleet and delivering benefits. If an improvement of this magnitude were true, it would be evident in fleet level miles-per-gallon and CO_2 levels (e.g., in

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150 *Environmental Protection Agency. January 2018. The Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends Report. https://www.epa.gov/fuel-economy-trends*

151 *U.S. Environmental Protection Agency, 2017. Greenhouse Gas Emission Standards for Light-Duty Vehicles Manufacturer Performance Report for the 2016 Model Year. Accessed from https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100TGIA.pdf*

152 *Input file with reference model year 2016 vehicle fleet from National Highway Safety Traffic Administration, 2018, "Compliance and Effects Modeling System." https://www.nhtsa.gov/corporate-average-fuel-economy/compliance-and-effects-modeling-system*

153 *Id*

EPA's compliance data, *Trends*[154] and *Manufacturer Performance*[155] reports). But, to the contrary, none of the quantifiable mpg or CO_2 benefits that would be associated with these additional rolling resistance improvements were reflected with any real-world evidence in the model year 2016 fleet. Again, this seems to be a case of the agencies artificially burying efficiency technology in the baseline, rendering it unusable in the post model year 2016 compliance scenarios.

In addition, the agencies adopt a new assumption that the fleet average coefficient of rolling resistance (0.009) is higher than that of the TAR (0.0075–0.009).[156] This is quite confusing and perhaps troubling, as it would imply that the fleet rolling resistance got worse, but the agencies are deciding to provide baseline credit as if there was more rolling resistance technology deployed. In the vehicle simulation modeling supporting the TAR, rolling resistance varied by vehicle class. For example, compact cars had a rolling resistance coefficient of 0.0075, whereas midsize cars were 0.008, and small SUVs 0.0084. The agencies appear to attribute this difference to the agencies' use of CBI on tire rolling resistance received since the TAR. This CBI was used to bin vehicles according to the level of rolling resistance reduction from the newly assumed fleet average 0.009. Using this logic, the agencies are essentially stating that nearly 20% of all vehicles achieve 0.0081 (or better) rolling resistance value, and more than 26% achieve 0.0072 (or better). These values were considered as ROLL0 for midsize and compact cars in the TAR. Rather than changing the definition of rolling resistance technology to include improvements *beyond* the baseline, the agencies have, instead, redefined the technology available in the baseline. Again, this reduces the number of vehicles that can use tire improvements in future compliance years within the agencies modeling framework, artificially forcing companies to use other, more expensive technologies.

Due to the very large cost and technology impact, and the lack of data substantiation by the agencies, the agencies must clearly and precisely share their absolute road load coefficients (i.e., the basis for any rolling resistance calculation) and exact estimated percent improvement (rather than binned percentage categories) for each vehicle make and model in the baseline and future modeled fleet, and their technical justification for each value. To not do so would obscure the agencies' methods. The agencies must also conduct two sensitivity analysis cases that assume that every baseline make and model is set to 0% rolling resistance improvement and set to the previous baseline rolling resistance (from the Draft TAR) to demonstrate how much the agencies' decision to load up more baseline technology affects the compliance scenarios, as it appears that the agencies may have made a unsupportable and non-rigorous assumption about rolling resistance technology across the models. Because of these types of changes that are opaquely buried in the agencies' datafiles and unexplained, we believe the

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[154] *Environmental Protection Agency. January 2018. The Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends Report. https://www.epa.gov/fuel-economy-trends*

[155] *U.S. Environmental Protection Agency, 2017. Greenhouse Gas Emission Standards for Light-Duty Vehicles Manufacturer Performance Report for the 2016 Model Year. Accessed from https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100TGIA.pdf*

[156] *PRIA section 6.3.10.1.3.1.1 at 446; Draft TAR section 5.4.2.6.1, Table 5.219 at 5-503*

agencies have to reissue a new regulatory analysis and allow an additional comment period for review of their methods and analysis.

14. Electric power steering, improved accessories, low-drag brakes

The agencies have likewise made several additional unjustified shifts in the baseline fleet in NHTSA's data files. From the model year 2015 baseline to the 2016 baseline, the agencies have deemed use of electric power steering improvements to have increased from 38.5% to 89% of vehicles sold; use of improved accessories to have increased from 0% to 20% of vehicles sold; and use of low drag brakes to have increased from 0% to 13% of vehicles sold.[157] Furthermore, the agencies have eliminated the TAR's first level of accessory improvement and kept only the second level. They have thus assumed that 100% of the 2015 baseline has shifted to the first level of accessory improvement, and a further 20% of those have adopted the second level, thus mysteriously burying even more of the accessory efficiency technology in the model year 2016 reference fleet. If there is comprehensive data basis for this shift, it remains undisclosed by the agencies.

Electric power steering, improved accessories, and low-drag brakes are worth 1-1.5%, 2%, and 0.8%, respectively, in efficiency improvement against baseline vehicle technology. However putting this technology in the baseline removes it from potential use in the 2017-2025 analysis, and it is not substantiated with data to show that the automakers deployed the technology in the real world. To substantiate this, agencies need to show data on how these improvements are evident in the fleet and delivering benefits. If an improvement of this magnitude were true, it would be evident in fleet level miles-per-gallon and CO_2 levels (e.g., in EPA's compliance data, *Trends* and *Manufacturer Performance* reports). But, to the contrary, none of the quantifiable mpg or CO2 benefits that would be associated with these additional electric power steering, improved accessories, and low-drag brakes were reflected with any real-world evidence in the model year 2016 fleet. This seems to again be a case of the agencies artificially burying efficiency technology in the baseline, rendering it unusable in the post model year 2016 compliance scenarios.

Due to the very large cost and technology impact, and the lack of data substantiation by the agencies, the agencies must clearly and precisely share their technical justification for including all each individual case of these new electric power steering, improved accessories, low-drag brake technologies by make and model. To not do so would obscure the agencies' methods. The agencies must also conduct two sensitivity analysis cases that assume that every baseline make and model is set to the same as the Draft TAR data to demonstrate how much the agencies' decision to load up more baseline technology affects the compliance scenarios.

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[157] *Input file with reference model year 2016 vehicle fleet from National Highway Safety Traffic Administration, 2018, "Compliance and Effects Modeling System." https://www.nhtsa.gov/corporate-average-fuel-economy/compliance-and-effects-modeling-system*

15. Air conditioning

Stating their rationale to harmonize the standards, EPA has proposed to exclude air conditioning refrigerants and leakage from average GHG performance calculations after model year 2020. This is inappropriate, as GHG-reduction technologies are available, cost-effective, and currently experiencing increased deployment by many companies due to the standards. As evidence of the technologies' availability and cost-effectiveness, at least 16 companies (BMW, Ford, Fiat-Chrysler, General Motors, Honda, Hyundai, Jaguar Land Rover, Kia, Mercedes, Mitsubishi, Nissan, Subaru, Tesla, Toyota, Volkswagen, Volvo) have deployed some leakage-related technologies and received GHG credits.[158] In addition, at least four companies (GM, Honda, Jaguar Land Rover, Fiat-Chrysler) have begun deploying low-global warming refrigerants, replacing the main refrigerant R-134a with HFO-1234yf.[159] EPA fails to acknowledge, much less discuss, these developments. This information is widely available in the U.S. EPA Manufacturer Performance Report.[160] This major oversight implies that U.S. EPA engineering experts that administer, review automaker technology, and enforce this aspect of the program have not been consulted in this decision.

Furthermore, we cannot find any analysis of the availability, cost, or cost-effectiveness of the emerging HFO-1234yf refrigerant technology in the NPRM or PRIA, when there were dozens of pages of assessment in the original rulemaking[161] and there have been many technology deployments by at least 16 automakers since.[162] Without offering credits in the GHG regulation, these technologies will not be deployed across the fleet, as they do not have associated consumer fuel-saving benefits that make them more attractive to consumers. Based on the extensive analysis in the original 2012 rulemaking and original 2017 Final Determination, it is clear that EPA has simply been incomplete in their technical assessment related to these refrigerant technologies and provisions within this rulemaking.

EPA has an obligation to reduce greenhouse gas emissions and do so cost-effectively. Automakers and their suppliers reacted to the regulation and began investing in, and utilizing, the available credit system for refrigerant-based credits, as this was indeed part of a cost-effective compliance approach to reduce emissions. This move to remove the refrigerant-related

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[158] *U.S. Environmental Protection Agency, 2017. Greenhouse Gas Emission Standards for Light-Duty Vehicles Manufacturer Performance Report for the 2016 Model Year. Accessed from https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100TGIA.pdf*

[159] *U.S. Environmental Protection Agency, 2017. Greenhouse Gas Emission Standards for Light-Duty Vehicles Manufacturer Performance Report for the 2016 Model Year. Accessed from https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100TGIA.pdf*

[160] *U.S. Environmental Protection Agency, 2017. Greenhouse Gas Emission Standards for Light-Duty Vehicles Manufacturer Performance Report for the 2016 Model Year. Accessed from https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100TGIA.pdf*

[161] *See "Air Conditioning Related Credits" at 77 Code of Federal Register (October 15, 2012), 62804-62810. Joint Technical Support Document: Final Rulemaking for 2017-2025 Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards Page 5-1 to 5-61*

[162] *U.S. Environmental Protection Agency, 2017. Greenhouse Gas Emission Standards for Light-Duty Vehicles Manufacturer Performance Report for the 2016 Model Year. Accessed from https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100TGIA.pdf*

aspects of the rule clearly demonstrates that the EPA is forgoing a known cost-effective technology that effectively removes technology from deployment without basis. As a result, the agencies have failed in their analysis of likely industry compliance with respect to the refrigerant technology and made an inappropriate conclusion to remove the refrigerant provisions after 2020.

If the agencies remove these refrigerants from the program, they will effectively be ignoring the effects of known substantial climate pollutants. Removing refrigerant credits that were previously available for reductions of 13.8 gram CO_2 per mile (g/mile) cars and 17.2 g/mile for light trucks inappropriately removes significant environmental protections, and it also undercuts existing investments by automakers and suppliers. Through model year 2016, based on U.S. EPA data[163], companies have deployed the refrigerant and leakage technologies up to a fleet average of 6 g/mi, or about 40% of the maximum fleet average of 15 g/mile.

EPA is obligated to adopt standards for the group of greenhouse gases, as specified in the related endangerment finding. This group of greenhouse gases includes the gases found in vehicle refrigerants and addressed by EPA's current provisions for control of these gases. There is no technical or other basis to remove the provisions currently in place that control these GHGs and are part of satisfying EPA's obligation to adopt standards that control emissions of the entire group of GHGs, not just some of them.[164] Nor is there a clear or better option put forward to develop a separate standard for air conditioning leakage and refrigerant substitution to recapture the lost benefits. EPA indicates that "If the agency moves forward with its proposal to eliminate these factors, EPA would consider whether it is appropriate to initiate a new rulemaking to regulate these programs independently, which could include an effective date that would result in no lapse in regulation of A/C leakage."[165] However, dropping a substantial amount of environmental protection for a vague statement that it might be picked up at a later point, while creating uncertainty for industry who is well along on a path to deploy the associated technology, is not acceptable. Considering this regulation's apparent overall bias toward less action, this appears to clearly be a move toward eliminating environmental protection, while making it appear *for the moment* as if EPA will perhaps eventually live up to its responsibility at some later date.

Based on our above assessment, the agencies have made an incorrect, unsupported, and invalid proposal to exclude leakage and replacement refrigeration provisions. The agencies must fully maintain the original air conditioning provisions and their application in setting the footprint-indexed performance standards as previously, up to 13.8 g/mile (passenger cars) and 17.2 g/mi (light trucks) more stringent GHG standards to incorporate their use from model year 2021 on. Otherwise the agencies would be arbitrarily removing a cost-effective technology and GHG provisions that deliver approximately 16% of the total required g/mile GHG reductions

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[163] *Ibid.*
[164] *See 77 FR 62624, 627, 672, 770 (October 15, 2012).*
[165] *83 Fed. Reg. at 43194*

from the existing 2017-2025 rules, and would amount to about 40% of the g/mile GHG reductions from just the 2021-2025 rules.[166]

Moreover, to appropriately model the adopted GHG standards through model year 2025, the agencies must include the widespread use of these air conditioning technology credits as applicable across all companies. The agencies have not done so, demonstrating that this appears to be another case where the agencies did not include the EPA's engineering expertise or compliance data.[167]

Eliminating this environmental protection on automotive refrigerant emissions—a cost-effective provision; one agreed to between the industry, the previous administration, and the states; and one that industry is planning to live up to—is bad public policy; we recommend that the EPA does not go forward with its proposed approach to eliminate the air conditioning provisions from the GHG program.

16. Off-cycle credit technologies

The agencies' assumptions regarding off-cycle credits (what the agencies propose to re-name as fuel consumption improvement values), and the model's treatment of those credits/values, are both deficient and contrary to real-world historical evidence and to any reasonable projection of likely future technology penetration.

The agencies sought comment on various flexibilities including the off-cycle crediting program.[168] In particular, the agencies requested comments on expanding the program to include more technology, streamlining the process to approve credits, and also potentially removing the off-cycle provision altogether. These proposed ideas are presented by the agencies despite providing less analysis of the associated technologies than was presented in the original 2012 rulemaking or EPA's 2017 Final Determination in the Mid-Term Evaluation that determined that the MY2022-2025 standards are appropriate under section 202(a).

In particular, the agencies have failed to correctly assess the technology, costs, and effectiveness of both available and projected off-cycle technologies. Off cycle technologies have proliferated much more quickly than the agencies projected. In the rulemaking for model years 2012-2016, these off-cycle provisions were established only for EPA but not for NHTSA i. In the model year 2017-2025 rulemaking these provisions were updated and expanded to include NHTSA. In that rulemaking the agencies projected just 2.5 g/mile on average for off-cycle credits in 2025. However, companies have already surpassed the agencies' projection, with the

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[166] *These calculations of 16% (of 2016-2025 emission levels) and 40% (of 2021-2025 emission levels) are based on the fleet going from 268 g/mile in 2016, to 221 g/mile in 2021, to 173 g/mile in 2025, and based on the car-truck average air conditioning credit of approximately 15.6 g/mile. Also see for more related info from Nic Lutsey and Aaron Isenstadt, 2018. How will off-cycle credits impact U.S. 2025 efficiency standards. https://www.theicct.org/publications/US-2025-off-cycle*

[167] *U.S. Environmental Protection Agency, 2017. Greenhouse Gas Emission Standards for Light-Duty Vehicles Manufacturer Performance Report for the 2016 Model Year. Accessed from https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100TGIA.pdf*

[168] *83 FR at 43444 and 43446-43447.*

use of off-cycle credits increasing to that level in model year 2016.[169] The use of off-cycle credits was worth more than 5 g/mile for individual companies like Fiat-Chrysler, Ford, and Jaguar Land Rover in model years 2015 and 2016.[170] The off-cycle technologies are cost-effectively being applied by automakers as part of multiple automakers' compliance strategies, and it is highly likely other automakers will adopt similar technologies. Simply adopting the leading technology in current use (through 2016) from each of the off-cycle technology areas would put the fleetwide off-cycle credit use at over 10 g/mile by 2020. This information is widely available in the U.S. EPA Manufacturer Performance Report,[171] and it is a major oversight to not analyze the current and projected usage and present such information.[172]

If the agencies had appropriately analyzed the implications of the off-cycle provisions, they would conclude that far greater use of the off-cycle provisions will occur by 2025, and this would greatly reduce the penetration of on-cycle technologies (e.g., engine, transmission, and hybrid), with major reductions in reducing overall GHG and CAFE compliance costs. The use of these provisions have been analyzed much more extensively by both U.S. EPA[173] and Lutsey and Isenstadt (2018).[174] than in the NPRM. It is clear that the agencies have presented an unsubstantiated, uninformed case in considering whether and how to expand and streamline the off-cycle provisions, or remove them, as well as in their compliance modeling of use and cost of this technology for compliance with the proposed freeze of the standards. The agencies do not provide a rationale for any of their proposals related to the off-cycle program, and specifically do not estimate technology cost, effectiveness estimates, future deployment by company, or cost-effectiveness within technology pathways. Without any description or rationale, the NPRM leaves stakeholders to wonder whether off-cycle technology was excluded from the analysis due to a bias to make the regulatory assessment of compliance costs artificially higher.

Any minimal and reasonable analysis of the how the off-cycle crediting provisions are being used by the industry would conclude that off-cycle credits will account for 15 g/mile (without further streamlining of the provisions), even up to 25 g/mile by 2025.[175] These levels of off-cycle technology use account for 10-25% of the total required 2017-2025 GHG reduction, and 35-56% of the total GHG reduction as currently required over 2022-2025[176]. These implications are large, yet they have not been considered in the compliance analysis that naively assumes off-

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[169] *U.S. Environmental Protection Agency, 2017. Greenhouse Gas Emission Standards for Light-Duty Vehicles Manufacturer Performance Report for the 2016 Model Year. Accessed from https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100TGIA.pdf*

[170] *Id.*

[171] *Id*

[172] *For example, the NPRM only discusses the use of off-cycle technologies that generate credits under the menu option, and states that MY2016 manufacturers received menu based credits averaging 2.5 g/mile. 83 FR at 43059, Table II-23.*

[173] *U.S. Environmental Protection Agency, 2017. Greenhouse Gas Emission Standards for Light-Duty Vehicles Manufacturer Performance Report for the 2016 Model Year. Accessed from https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100TGIA.pdf*

[174] *Nic Lutsey and Aaron Isenstadt, 2018. How will off-cycle credits impact U.S. 2025 efficiency standards. https://www.theicct.org/publications/US-2025-off-cycle*

[175] Ibid.

[176] *Ibid*

cycle credit use in model year 2025 is approximately the same as model year 2016 at about 2.5 g/mile.[177] The agencies need to explicitly include projections that describe how, with which technologies, and on which models automakers are likely to employ off-cycle technologies and receive well over 15 g/mile by 2025 off-cycle technologies, otherwise they appear to be purposely obscuring a known, widely used, and cost-effective path toward compliance on which nearly all automakers are clearly and obviously pursuing and increasing usage.

This is not to say that there are no concerns about the current process for validation of off-cycle technologies. It is concerning how the agencies appear to disregard the need for robust evidence that clearly indicates every off-cycle technology has real-world benefits.[178] If the agencies allow more use of off-cycle credits without clear validation of their real-world benefits, the regulations cannot serve their intended objectives to reduce GHG and fuel use. Allowing greater use of off-cycle technologies without validated real-world benefit would effectively be allowing more emissions and higher fuel use for any given stringency level. The off-cycle provisions should not be changed unless they are studied at least as rigorously as the test-cycle technologies that are analyzed as the primary means of compliance. However, the agencies have not done so. The manner in which the agencies have proposed to streamline the approval process[179] and grant more technologies would fail this basic test. With the large implications of the proposed off-cycle crediting provisions, the regulatory agencies cannot credibly analyze the appropriateness of the effect of these proposals on the current 2025 standards or alternatives without fully analyzing the off-cycle credit provision and the applicable technologies.

At the other extreme, the proposal to eliminate the off-cycle program is also unwarranted. [180] As described above, the agencies appear to have ignored the most recent data on technologies being deployed in significant numbers by leading companies, which technologies have resulted in significant, real-world reductions in GHG emissions and fuel consumption. Without robust analysis undermining this empirical record, the agencies must maintain the 2017-2025 provisions for off-cycle technologies. At the same time, for the reasons described above, they also should not finalize any expansion or streamlining of the off-cycle credit program.

This provision, as much as any in the rulemaking, shows how profoundly unthoughtful the agencies have been in thinking through all the regulatory elements and their actual implications for technology deployment. The off-cycle credit program, which could be worth up to half of all the total GHG reduction as currently required over 2022-2025 model years[181] is proposed to either be strengthened or eliminated, without any significant analysis. Based on essentially no analysis, the agencies are proposing two extremes of streamlining or eliminating a key part of

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[177] *Based on 83 Fed. Reg. at 43160, Table II-79, fleet-wide off-cycle use through model year 2025 appears to remain at less than 3 g/mile CO_2, essentially showing the agencies either made no effort to analyze the trend and automakers persistent attempts to get far more off-cycle technologies approved and credits, or that they are ignoring these credit trends in order to hide a highly cost-effective technology.*

[178] *Nic Lutsey and Aaron Isenstadt, 2018. How will off-cycle credits impact U.S. 2025 efficiency standards. https://www.theicct.org/publications/US-2025-off-cycle*

[179] *83 FR at 43444.*

[180] *Nic Lutsey and Aaron Isenstadt, 2018. How will off-cycle credits impact U.S. 2025 efficiency standards. https://www.theicct.org/publications/US-2025-off-cycle*

[181] *Ibid*

the regulation. Considering this is a cost-effective provision—and one agreed to by the industry, the previous administration, and the states offering a proposal that could swing either way is simply bad public policy. We strongly recommend that the agencies maintain the off-cycle program as is.

Regardless of the chosen policy path, it is necessary that the agencies appropriately reflect that the fleet will use at least 15 g/mile in off-cycle technology to comply with the Augural standards, and analyze and project the specific technologies automakers will use to do so. In the real world, off-cycle technologies are more cost-effective, and are being adopted in advance of, many advanced engine technologies (e.g., turbocharging level 2) or mild hybrid technology.[182] This is more consistent with automaker technology deployment patterns today than the compliance pathways modeled in the NPRM. If the agencies do not make this change in their baseline and modeling, their modeling of industry compliance will be erroneous by ignoring mainstream existing industry technology with trends that are clearly showing increasing adoption of off-cycle technologies that are evidently cost-effective for most automakers in the baseline 2016 fleet.

Because of this glaring omission of what is a top auto industry compliance approach and top request for flexibility, we believe the agencies have to reissue a new regulatory analysis that includes at least 15 g/mile in off-cycle technology use in the central regulatory scenario, and allow an additional comment period for public review.

In summary, as the section demonstrates, there are significant errors in how the agencies have developed their primary technology inputs for their regulatory analysis. Our findings are corroborated by EPA's communications with NHTSA officials, as shared in interagency emails and posted in the rulemaking docket. EPA notified NHTSA of many technologies having incorrect effectiveness values and poor assumptions on technology application which are inconsistent with the trends in the current vehicle market:

> "EPA has observed and presented to NHTSA that several of their inputs regarding technology effectiveness are incorrect. These technologies include some applications of advanced transmissions, 12V stop/start, cooled EGR (CEGR), crank integrated starter generator (CISG), turbo-charged GDI engines, strong hybrids and the application of high compression ratio engines (HCR1). For each of these technologies EPA has identified either errors in the input data or incorrect assumptions regarding the application of the technology which are inconsistent with trends seen in the current vehicle market. Each incorrect technology input contributes to a higher estimate of average vehicle cost to meet future standards."[183]

Based on our research into the rulemaking data, and as discussed above, there is no evidence that NHTSA responded to correct these incorrect data inputs that EPA pointed out.

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[182] *Ibid*

[183] *"Email 5": Email_5_-_Email_from_William_Charmley_to_Chandana_Achanta_-_June_18,_2018. https://www.regulations.gov/document?D=EPA-HQ-OAR-2018-0283-0453. Page 57.*

B. Technology packages and pathways

In addition to the agencies' invalid assessment of several of the individual technologies, the agencies assessment of combinations of technologies in packages that are used in all their compliance scenarios is erroneous in several important ways.

1. Vehicle simulation modeling

The latest analysis for the NPRM should improve upon the body of analytical work in the previous rulemakings. However, this rulemaking relies upon a modeling tool and inputs that have largely dismissed the seminal, rigorous, and well-vetted analysis used in the EPA analysis in the 2016 TAR and the original Final Determination in January 2017.

Based on the ICCT's global analysis of vehicle regulations, the EPA's physics-based ALPHA modeling offers the most sophisticated and thorough modeling of the applicable technologies that has ever been conducted. The EPA modeling is based on systematic modeling of technologies and their synergies. It was built and improved upon by extensive modeling by and with Ricardo.[184] The EPA approach incorporated National Academies input at multiple stages, including to inform the development of the initial Ricardo vehicle simulation and the follow-on ALPHA development, benchmarking engines to develop robust engine maps, the use of engineering teardown analysis for costs, and its method for estimating the learning-by-doing for future year costs.[185] It has included many peer reviews at many stages of the modeling and the associated technical reports published by engineers in many technical journal articles and conference proceedings.[186,187] This previous work in the EPA analysis in the TAR also used state-of-the-art engine maps based on benchmarked high-efficiency engines.[188] Despite these rigorous advances in vehicle simulation modeling, it appears that the agencies have inexplicably abandoned this approach, expressly disregarding the EPA benchmarked engines, ALPHA modeling, and all its enhancements since the last rulemaking.[189]

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[184] *77 FR at 62702, 62711. Also see Joint Technical Support Document: Final Rulemaking for 2017-2025 Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards, beginning page 3-76*

[185] *Wililam Charmley, 2018. Presentation to National Academies of Science Committee on the Assessment of Technologies for Improving Fuel Economy of Light-Duty Vehicles – Phase 3. http://sites.nationalacademies.org/cs/groups/depssite/documents/webpage/deps_188071.pptx*

[186] *Environmental Protection Agency. Advanced Light-Duty Powertrain and Hybrid Analysis (ALPHA) Tool. https://www.epa.gov/regulations-emissions-vehicles-and-engines/advanced-light-duty-powertrain-and-hybrid-analysis-alpha*

[187] *Wililam Charmley, 2018. Presentation to National Academies of Science Committee on the Assessment of Technologies for Improving Fuel Economy of Light-Duty Vehicles – Phase 3. http://sites.nationalacademies.org/cs/groups/depssite/documents/webpage/deps_188071.pptx*

[188] *Environmental Protection Agency. Engine Mapping Process Documents. https://www.epa.gov/regulations-emissions-vehicles-and-engines/advanced-light-duty-powertrain-and-hybrid-analysis-alpha#engine-mapping and Benchmarking Advanced Low Emission Light-Duty Vehicle Technology. https://www.epa.gov/vehicle-and-fuel-emissions-testing/benchmarking-advanced-low-emission-light-duty-vehicle-technology*

[189] This discussion refers to modeling, because it is the combination of the vehicle simulation model itself as well as all the inputs (such as engine maps) and technology pathways that lead to modeling results.

Instead, the agencies have relied on inputs based on Argonne National Laboratory's Autonomie modeling and relied upon generally older engine maps than the EPA data and modeling that underpinned the original Proposed and Final Determination. The modeling used in the NPRM is less rigorous and fewer peer review processes have been conducted to improve the work. The agencies insufficiently defended their choice of vehicle simulation model and outdated inputs. We have flagged dozens of technology and cost issues throughout these comments that any serious peer-review process would have identified and forced the NHTSA and or the Automomie modeling team to fix before going forward with a major rulemaking based on their modeling approach.

Engine maps. To accurately estimate state-of-the art technology, the foundation is up-to-date, state-of-the-art engine maps as inputs and to ensure realistic vehicle simulation modeling. The heart of this is the engine maps. The EPA has a world-class spectrum of benchmarked engines that is apparently vastly superior to what the agencies have presented in the rulemaking . EPA's benchmarked engines for the applicable advanced-technology engines include the following: [190]

- Turbocharged engines
  - 1.6L Ford EcoBoost –2013 Ford Focus (Euro)
  - 1.6L Ford EcoBoost – 2013 Ford Escape
  - 1.6L PSA Valvetronic turbo – 2012 Peugeot
  - 2.7L V6 EcoBoost (2015 Ford F150)
  - 1.5L I4 (2016 Honda Civic)
  - 2.5L I4 Skyactiv-G (Mazda CX-9)
  - 1.0L I3 EcoBoost (2014 Ford Fiesta)
  - 2.0L I4 (VW) with and without Miller cycle operation
  - 1.4L I4 (VW) – from a copyrighted 2016 Ricardo Report
  - Tula 'Dynamic Skip Fire' I4 turbocharged
  - GT-Power modeling of cooled-EGR and Variable Nozzle Turbocharger/Variable Geometry Turbocharger (VNT/VGT)
- Naturally aspirated, high-compression ratio, and cylinder deactivation engines
  - 2.5L I4 Ecotec engine - 2013 GM Malibu
  - 2.5L I4 Skyactiv – 2014 Mazda 6
  - 2.0L I4 Skyactiv – 2014 Mazda 3 (13:1 CR)
  - 2.0L I4 Skyactiv – 2014 Mazda 3 (14:1 CR – Euro)
  - 4.3L V6 Ecotec3 with cylinder deac - 2014 GM Silverado 1500 2WD
  - 2.5L I4 Toyota TNGA – 2018 Toyota Camry (in-process)
  - 2.5L I4 TNGA prototype engine (from Toyota Aachen paper)
  - 4.3L V6 Ecotec3 with cylinder deac - 2014 GM Silverado 1500 2WD
  - 6.2L V8 GM – 2011 Tula demonstration of 'dynamic skip fire' in GMC Denali
  - 1.8L I4 VW Jetta – 2015 Tula demonstration of 'dynamic skip fire' (in-process)

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[190] *Wililam Charmley, 2018. Presentation to National Academies of Science Committee on the Assessment of Technologies for Improving Fuel Economy of Light-Duty Vehicles – Phase 3. http://sites.nationalacademies.org/cs/groups/depssite/documents/webpage/deps_188071.pptx*

- Tula 'Dynamic Skip Fire' V8 naturally aspirated engines
- Prototype Mazda SkyActiv with 14:1 CR + Cooled EGR and high energy ignition

Instead of using this immense resource of laboratory data, the rulemaking is predicated upon a handful of engine maps by IAV. Based on our reading of the NPRM and its PRIA, the rulemaking is based primarily on 5 engine maps developed IAV to model advanced engines in Autonomie: [191]

- Engine #12: Turbo 1.6L direct injection with variable valve timing and lift
  - Engine #13: Downsized version of engine #12
  - Engine #14: CEGR added to engine #13
- Engine #24: Model year 2014 SkyActiv 2.0L (HCR1)
  - Engine #25: CEGR+DEAC added to engine #24 (HCR2)

To analyze the advanced efficiency technologies, the agencies essentially decided to use the more limited IAV modeling of two engines (Engine 12 and 24), with three derivatives of those engines, without advanced turbocharging of greater than 24 bar, Miller Cycle, or e-boost engines. Beyond the question of the limited IAV-based engine maps that used for the advanced technologies, there also appear to be clear errors in those engine maps. Based on the interagency dialogue between EPA and NHTSA, regarding engine #12, EPA indicated "Based on the information provided in this NPRM, the assumptions used for fuel octane, heating value, and carbon content do not appear to be internally consistent and representative of GHG performance of turbocharged engines over the certification cycles"[192]. Based on our reading of the applicable documentation, it appears to be clear that no changes were made to the engine map by the agencies to address this problem,[193] and this problem essentially affect all engines on the turbocharged engine pathway. It is also unclear if or how engines have validated their derivative simulated engines #13 and #14 with physical testing and/or state-of-the-art vehicle simulation modeling to the level of quality of EPA's simulation modeling. Engines #24 and #25 are sourced as coming from EPA data,[194] which again signifies that the real sources for the best available information is from the more comprehensive benchmarked engine data for engine maps from the EPA expert engineers.

Furthermore, beyond the clear disparity in the applicable engine lists utilized above, there is an indication that NHTSA did not utilize all EPA's more extensive engine technology based on the interagency dialogue between EPA and NHTSA: "EPA has not been consulted by NHTSA regarding a list of engine technologies which NHTSA should consider for the purposes of this

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[191] *See PRIA, starting page 270 and page 287. Also see Argonne National Laboratory. A Detailed Vehicle Simulation Process To Support CAFE Standards. https://www.regulations.gov/document?D=NHTSA-2018-0067-0007, starting at page 177*

[192] *"EO_12866_Review_EPA_comments_on_NPRM_and_Preliminary_RIA_sent_to_OMB,_July_26,_2018". https://www.regulations.gov/document?D=EPA-HQ-OAR-2018-0283-0453. Page 1058.*

[193] *Based on a comparison of PRIA section 6.3.2.2.20.9 and Figure 6-81*

[194] *See . Also see Argonne National Laboratory. A Detailed Vehicle Simulation Process To Support CAFE Standards. https://www.regulations.gov/document?D=NHTSA-2018-0067-0007, see page 189 and 190 for reference to EPA, 2016 as the source of these engines.*

Notice of Proposed Rulemaking"[195] More generally, the agencies have a responsibility to more clearly and consistently show sources for all their assumed engine effectiveness values from the engine maps cases and as presented in tables in NPRM and PRIA, where there are many different effectiveness values for various technologies throughout. Based on the interagency dialogue between EPA and NHTSA, it is clear that EPA tended to agree with this:

> "NHTSA cites to manufacturer CBI in numerous instances throughout this table. In most cases shown in the table, publicly available data are available for these technologies from many sources, including EPA benchmarking testing, vehicle manufacturer data, and Tier 1 supplier data from peer-reviewed engineering journal publications. Whenever possible, data from publicly available sources that can be independently scrutinized should be chosen over Manufacturer's CBI data for transparency and to provide the public with a meaningful opportunity to comment."[196]

As a result we ask the agencies to clearly specify every instance where confidential business information was used, and also specify each place that information was used when publicly available data were available. We ask the agencies to summarize these instances in a comprehensive table in order to transparently reveal their approach to handling the technology inputs for all their models. In addition we ask that the agencies' clearly show the publicly available data that was not used, compare the public data with the confidential business information that was used, and defend their choice to use the industry data.

Based on our reading of the proposed rule and its documentation, it is clear that the agencies inappropriately handled two aspects of their IAV-based engine maps in a manner that shows the agencies' bias and makes their modeling with the engine maps they use in Autonomie and CAFE invalid. The IAV modeling and agency engine maps were adjusted in a way that unjustifiably and artificially reduces the effectiveness of the technologies. The entire set of turbocharging technology engine maps were updated to reflect operation on 87 AKI regular octane fuel, which the agencies explained as a necessary change because they believed the previously used agency maps used in the TAR required the use of premium fuel.[197]

However, the agencies are ignoring how the agencies had already previously addressed this question. EPA's testing shows CO_2 emissions using 87 AKI, 10% ethanol (E10) fuel actually reduces GHG emissions over the combined cycle compared to Tier 2, 0% ethanol (E0), 93 AKI fuel.[198] This reveals that the basic adjustment the agencies are deciding to make, due the way it is a crude adjustment rather than base on rigorous study, is in the wrong direction for some

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[195] *"EO_12866_Review_EPA_comments_on_NPRM_and_Preliminary_RIA_sent_to_OMB,_July_26,_2018". https://www.regulations.gov/document?D=EPA-HQ-OAR-2018-0283-0453. Page 1021.*

[196] *"EO_12866_Review_EPA_comments_on_the_NPRM_sent_to_OMB,_June_29,_2018". https://www.regulations.gov/document?D=EPA-HQ-OAR-2018-0283-0453. Page 37.*

[197] *83 Fed Reg page 43037. Also see PRIA p 270. For figures illustrating the adjustment see page 288 (Figure 6-83) and page 289 (Figure 6-84)*

[198] *EPA, 2016. 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. Table 2.71, p 2-320*

technologies because GHG-per-mile emissions can actually being lower with the switch to higher octane ethanol blends. The agencies can easily fix this by relying on EPA's better vetted engine maps, which would ensure their results are valid, and at least directionally correct. EPA has accounted for cost and effectiveness of technology used to protect for operation on regular octane fuel[199] by increasing costs and reducing effectiveness. In addition, manufacturers are required to confirm that vehicles not labeled as "premium fuel required" do not show emissions changes over all test cycles (including fuel economy label test cycles like the US06) when using regular octane fuel.[200] Reducing effectiveness for fuel differences, in the way that the agencies have done with IAV engine maps, is unrealistic and inappropriate.

The handling of CEGR in the engine maps is another indication of the limitations that agencies' approach, as compared with EPA's valid, rigorous, and well documented engine maps. The IAV handling of CEGR is not correct for use in this rulemaking. In IAV's handling of CEGR, the technology is used for knock abatement in the NPRM.[201] This helps to explains why the agencies in the NPRM (and NHTSA in the Draft TAR) are falsely showing no benefit of CEGR, as they have simply modeled the incorrectly chosen a CEGR technology that is not applicable. CEGR is manifestly capable of delivering GHG and efficiency benefits, as it is being deployed by manufacturers, as discussed above. However IAV (and thus Autonomie and CAFE model) are analyzing something different – a knock-abatement form of CEGR technology rather than CEGR as an efficiency technology. Modeling the type of CEGR technology the delivers efficiency benefits is the purpose of the rulemaking's assessment of available efficiency technologies. The agencies explicitly state that, "[b]ecause IAV's models are not trained for emissions, cEGR was only considered for areas that are knock-limited and/or to reduce combustion temperatures."[202] In the Draft TAR[203] and in the Proposed Determination,[204] EPA illustrates how important CEGR can be for reducing emissions and fuel consumption at part-load, which is more important for drive-cycle effectiveness.[205] The real-world examples of engines with CEGR described above demonstrate how CEGR is a viable and attractive efficiency technology being deployed by companies. No explanation is given as to why EPA's modeling is not considered for application of CEGR, as the technology has high potential to reduce GHG emissions and increase efficiency, and EPA has demonstrated it can properly model it based on its validated data. Had EPA's extensive modeling been incorporated in the NPRM, the effectiveness of CEGR would have been more realistic.

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199 *Ibid.*

200 *EPA, 2016. 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. Table 2.71, p 2-221*

201 *PRIA, page 271.*

202 *Ibid.*

203 *Draft TAR, Figure 5.99*

204 *EPA, 2016.* 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. *Fig 2.106*

205 *EPA, 2016.* 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. *PD p2-302*

Unfortunately, the agencies indicate that there are other engines that IAV did study, but that the agencies did not include: The agencies *did include* more advanced turbocharging (24- to 27 bar), Miller Cycle, turbocharging with cylinder deactivation, e-boost, and variable compression ratio.[206] In addition the IAV modeling included technology combinations that the agency pathways are explicitly disallowing. For example, IAV in engine map 25a, modeled an advanced cylinder deactivation (ADEAC) engine based on a turbo engine with CEGR and VVT, yet the agencies make TURBO and ADEAC exclusive of one another in their technology pathways (which we point out is clearly not appropriate from an engineering standpoint). Note that these are all areas above that we mention above as critical for the agencies to assess the viable engine technologies, and the unconstrainted use of all viable technology combinations and pathways, for the timeframe of this rulemaking. This is mystifying: the agencies knowingly disregarded EPA's benchmarked engine maps, instead opting to only use a more limited set of engine maps, and then they chose to not use all of the ones available. We do not know the reasons; for example, either the engine maps were not of high quality, were not well vetted, could not be ably utilized in the Autonomie model, were not reviewed by the engineering experts at the EPA, or perhaps the agency staff decided not to use them for other reasons. Regardless it is clear that the agencies have decided to disregard the superior data for a limited and less credible set of engine maps.

After the choice of engine maps, the critical question for the agencies was about whether ALPHA or Autonomie modeling was best to handle the complex synergies of all the technology packages. The agencies justify their sole reliance on Autonomie to develop model inputs by claiming that the Autonomie model addresses several analytical needs, and that several years have been spent by DOE developing, applying, and expanding the means to use distributed computing to exercise its full-vehicle simulation. It has scalability and flexibility in terms of expanding the set of technologies used for research purposes. The agencies appear to place special weight simply on convenience and how Autonomie is used by the U.S. Department of Energy, which uses the tool in making budget and other planning decision for its Vehicle Technologies Office, and that it meets EPA legal requirements, which do not require that it use any specific model.[207]

In addition, one particular issue is especially troubling regarding the agencies' decisions regarding their engine maps inputs. EPA's communications with NHTSA officials, as shared in interagency emails and posted in the rulemaking docket, reveal that EPA notified NHTSA that their data were clearly out-of-date:

> "EPA has also noted that more recent and representative data are available. In their Draft TAR analysis, NHTSA applied engine maps developed by IAV in 2013 from a DOE-funded project unrelated to the assessment of CAFE standards. During the course of EPA's evaluation of the NHTSA analysis, NHTSA informed EPA that they were using the

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[206] *PRIA figures 6-115, 6-116, 6-58 through 6-64, 6-111 through 6-113*

[207] *The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021–2026 Passenger Cars and Light Trucks, 83 Fed. Reg. at 43000 and 43001. And also there is a mention at PRIA at p 188 to say the OMEGA model was previously used.*

> same IAV engine maps for their NPRM analysis. These maps were out of date at the time of the 2016 Draft TAR and we have additional, and newer data, further strengthening our conclusions that the engine maps used in the CAFE analysis are not representative of what the industry is currently producing and will be producing in the 2020~2030 time frame assessed in the CAFE model. This out-of-date characterization of modern engines also contributes to the higher estimated vehicle cost."[208]

Based on our research into the rulemaking data, there is no evidence that NHTSA responded to correct these incorrect data engine map inputs that EPA pointed out or updated the engine maps in question. In fact, despite being notified of this, NHTSA still used the same IAV engine maps in the NPRM and even reduced the efficiency of the simulated engines, as indicated above.

Vehicle performance. There are also substantial and pervasive errors in how the agencies have developed nearly many of their primary technology inputs for their regulatory analysis related to their deficient analysis of vehicle performance. The agencies, in analyzing the technologies above and then developing their multi-technology packages from them, made major changes in the vehicle powertrain and load reduction. With such shifts from the vehicle technology packages, there was apparently no calibration or adjustment to ensure the vehicles in future years deliver similar performance. An example is that when vehicle lightweighting is deployed at up to a 7% mass reduction, the engine is not resized even though less power would be needed for the lighter vehicle, meaning any such vehicles inherently are higher-performance.[209] As the EPA points out, "mass reduction, advanced transmissions, or other load reduction will increase acceleration performance. This additional benefit is not accounted for in the CAFE model."[210] The result of this is that the "CAFE Model Projects Unquantified and Unmonetized Increase in Vehicle Performance."[211] We have found no evidence that the agencies have solved this issue, and we address this issue further in Section II.C below.

Vehicle simulation modeling. It is notable that the agencies' explanation and justification for its sole reliance on Autonomie full-vehicle simulation modeling and rejection of ALPHA full-vehicle simulation modeling fails to discuss ALPHA modeling in detail and to compare and contrast the two models. The EPA cannot select its modeling tool arbitrarily, yet it appears that the EPA has whimsically shifted from an extremely well-vetted, up-to-date, industry-grade modeling tool to a less-vetted, academic-grade framework with outdated inputs without even attempt to scrutinize the change. Moreover, the agencies are legally obligated to acknowledge and explain when they change position. The agencies cannot simply ignore that EPA previously concluded that the ALPHA modeling accurately projected real-world effects of technologies and

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[208] *"Email 5": Email_5_-_Email_from_William_Charmley_to_Chandana_Achanta_-_June_18,_2018. https://www.regulations.gov/document?D=EPA-HQ-OAR-2018-0283-0453. Page 57.*

[209] *"Email 5": Email_5_-_Email_from_William_Charmley_to_Chandana_Achanta_-_June_18,_2018. https://www.regulations.gov/document?D=EPA-HQ-OAR-2018-0283-0453. Page 106. "Engines are resized only when constructing an initial conventional or hybrid package or when applying over 7.5% mass reduction"*

[210] *Ibid*

[211] *Ibid*

technology packages.[212] Instead, the agencies must now explain and directly compare the modeled efficiency differences and how they have fundamentally altered the regulatory technology penetration and compliance cost estimations. The modeled vehicle technology outputs, because they are so fundamental as the starting point for nearly every other aspect of regulatory assessment (including technology penetration, compliance cost, rebound effect, overall cost-benefit analysis), deserve the most scrutiny and vetting of all agency decisions. However, counterintuitively, the agencies have barely scrutinized and discussed this deviation from the EPA's TAR, 2016 Final TSD, Proposed Determination, and Final Determination.

We recommend that the agencies conduct a systematic comparison of the Autonomie modeling system and ALPHA modeling, and state why Autonomie modeling was selected for use over ALPHA's modeling of technologies and synergies. ALPHA modeling, of course, also can serve as a corroborative cross-check on the Autonomie simulations (and vice versa), as occurred in the TAR.[213] Otherwise, it seems obvious that the agencies have subjectively decided to use the modeling that increases the modeled cost, providing further evidence of a high degree of bias without an objective accounting of the methodological differences and the sensitivity of the results to their new decision. Only with a thorough comparison of the ALPHA and Autonomie modeling and their validity can the agencies explain why the millions of dollars and dozens of person-years of expert technical work by expert auto industry engineering firms FEV and Ricardo, and EPA engineers, have been forgone for what seems like a hasty and opportunistic use of the NHTSA and Argonne analysis.

Part of this recommended comparison should be to assess how the agencies choice of Autonomie modeling versus ALPHA modeling impacts each of the major 2025 technology package synergies and where and why Autonomie provide different results from ALPHA. Because ALPHA is the dominant, preferred, and better-vetted modeling and was used in the original Proposed and Final Determination, the agencies are responsible for assessing and describing how the use of the ALPHA modeling would result in a different regulatory result for their analysis of the 2017-2025 adopted GHG and Augural CAFE standards. While the agencies are conducting a proper vetting of their NPRM's foundational Autonomie modeling, they must also defend why they appear to have chosen to dismiss the be superior and better vetted technology modeling approach with more thorough and state-of-the-art advanced powertrain systems modeling and engine maps from the EPA ALPHA modeling, as discussed above.

As part of this assessment of the modeling frameworks, the agencies should also disclose how much commercial business is conducted by the Ricardo, IAV, and Argonne Autonomie teams that underpin the modeling of EPA and NHTSA, respectively, including how much related research they have done for auto industry clients over the past ten years. We mention this because we strongly suspect that Ricardo, upon which EPA built its ALPHA model, has done at

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[212] EPA has explained in the past why it developed ALPHA for use in modeling. A recent discussion occurred in the mid-term evaluation, See EPA's Technical Support Document 2-268 for the proposed Determination and Response to Comments document pp 25 – 29, for the Final Determination. EPA must identify and describe how and why it developed these modeling tools and inputs and used them, instead of Autonomie modeling and related inputs, in the past including the very recent past, and fully justify the abrupt departure for this rulemaking.

[213] See Draft TAR at pp. 2-9 to 2-10.

least an order of magnitude (in number of projects, person-hours, and budget) more work with and for the automotive industry than the IAV and Autonomie teams have in direct work for automotive industry clients. A conventional government procurement effort that competitively vets potential research expert teams would presumably have selected for such automotive industry credentials and experience, yet it appears that the agencies are wholly deferring to Autonomie's less rigorous research-grade modeling framework and data due to convenience and easier access by the NHTSA research team, rather than for any technical improvement, and this is to the detriment of showing clear understanding of real-world automotive engineering developments (as demonstrated by many erroneous technology combination results throughout these comments).

Related to this, we recommend the agencies disclose how and whether the ALPHA and Autonomie models have been routinely strengthened by incorporating cutting edge 2020-2025 automotive technologies to ensure they reflect the available improvements for the technologies discussed above. It appears the agencies have opted to use a simpler, less-vetted model with more outdated and falsely conservative assumptions that do not reflect emerging efficiency advancements. Specifically, per the comments elsewhere in these comments, we mention two areas in particular. First, there is the question of the benchmarked engines by EPA and IAV and whether each can reasonably stand as a foundation for automotive developments and technology combinations discussed in Section I above. Second, there is the question about whether the ALPHA and Autonomie models realistically and validly model synergies between technologies. For example we mentioned the problem of CEGR not having a benefit above and the transmission issues in Table 1. Below there are additional synergy issues with turbocharging effectiveness in Figure 2, and other synergy issues in Table 5. A systematic comparison is needed as a matter of due diligence on the agencies' choice to dismiss the original work, and it would also ultimately bring the immense amount of person-years of recent and applicable engineering work by EPA engineers and their contractors into this rulemaking process.

Similar to scrutinizing the modeling approach, the agencies must directly compare every efficiency technology in the 2016 Draft TAR and original EPA TSD and Proposed and Final Determination analysis against the NPRM and explicitly show and defend every change that has been made. As evident from the comments above, the opaque and often counterintuitive and erroneous results within the input and output files seem designed to obscure the complete list of technical input changes that contribute to the agencies essentially increasing the Adopted 2025 and Augural 2025 compliance cost by 2-3 times since the TAR. The agencies must also compare all the major technology package pathways (i.e., all combinations with high uptake in the Adopted and Augural 2025 standards) in the current NPRM versus the 2016 Draft TAR and the 2016 TSD and original Final Determination analysis. Without doing so, it otherwise appears that the agencies switched from a better-vetted model and system of inputs with more recent input data to a less-vetted model and system of inputs as a way to bury many dozens of changes without transparency or expert assessment (as illustrated in the above errors and invalidated data on individual technologies). The three aspects of technical inputs, technology pathways, and modeling methodology are named together here because they appear to be

interlinked in ways that only the agency staff can disentangle to describe which 10 or 20 or 100 changes are responsible for approximately doubling compliance cost.

Related to this, the agencies must conduct and disclose a systematic investigation and comparison of the modeling work of EPA's, Ricardo's, and Argonne's 2014-2018 model year engine benchmarking and modeling of top engine and transmission models. The findings from above indicate that much of the EPA benchmarking and state-of-the-art modeling has not been included in the NHTSA and Argonne modeling, and this contributes to many erroneous findings that suggest there is only limited technology improvement available. While the agencies are in their process of conducting a proper vetting of their NPRM's foundational Autonomie-based modeling, we recommend that they rely on what appears to the be superior and better vetted technology modeling approach with more thorough and state-of-the-art advanced powertrain systems modeling and engine maps from the EPA ALPHA modeling.

2. Technology availability, applicability, and pathway constraints.

The agencies have created a system of technology constraints that illogically restrict the adoption of technology in the future. The agencies essentially are imposing modelling constraints that restrict when technologies can be introduced on models and preclude vehicle models from migrating between different technologies over the 9 years of their analysis from model year 2016 through 2025 for the Augural standards.[214] For instance, companies in many cases are not allowed to adopt technologies that aren't already on their 2016 fleet, such as switching to HCR in lieu of turbocharged downsizing or switching from conventional automatic transmissions to DCTs. The logic that the agencies have hard-coded into their algorithm and methodological approach for their technology pathways, and their fleet modeling constraints on "skips" in the market input file, limits the migration and deployment of technology in a way that defies recent automotive history. This is evident even within the agencies' own data used to develop their rulemaking.

To demonstrate how arbitrary and unrealistic the agency's proposed technology constraints are, Figure 1 and Table 3 show that there are approximately 50 instances that we found from the agencies' data where a company that did not have a given powertrain technology in their 2008 model year vehicles had that technology deployed on their 2016 model year vehicles. Table 3 illustrates the rapid increase in technology deployment in less than 9 years, including naming the associated companies that newly deployed each technology by 2016. It shows how the agencies' decisions to restrict available technology on a company-specific and fleet-wide basis to their current product offerings are contrary to recent industry practice and are thus invalid.

[214] In addition to the discussion here, please see discussion above with respect to HCR1 and HCR2, Turbodownsizing, and cylinder deactivation technologies, among others.

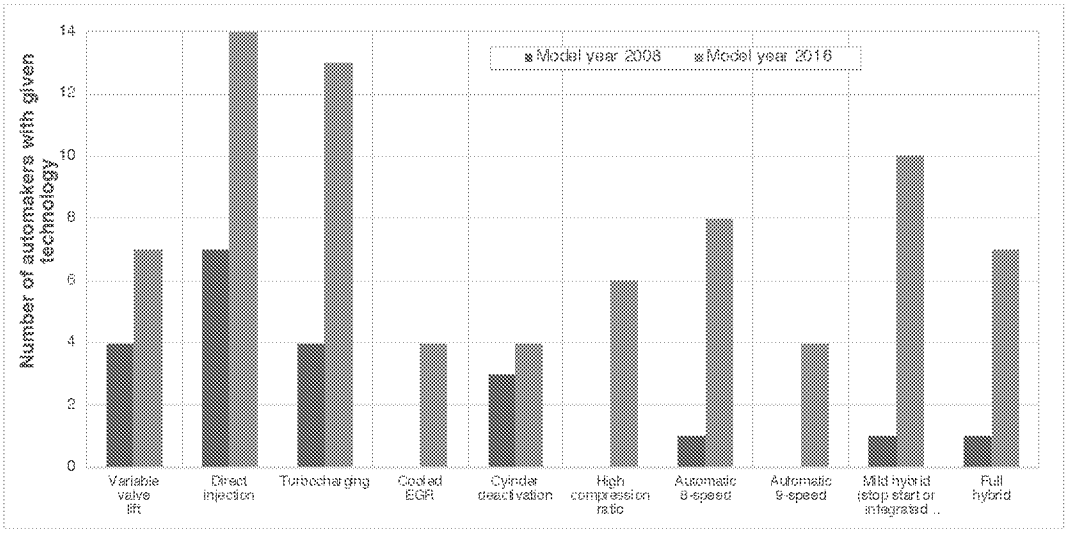

Figure 1. Number of automakers with given powertrain technology, 2008 and 2016[215]

[215] *Datafiles from National Highway Safety Traffic Administration, 2018, "Compliance and Effects Modeling System." https://www.nhtsa.gov/corporate-average-fuel-economy/compliance-and-effects-modeling-system, and datafiles from U.S. EPA original 2017-2025 rulemaking https://www.epa.gov/regulations-emissions-vehicles-and-engines/final-rule-model-year-2017-and-later-light-duty-vehicle*

Table 3. Companies with given technology deployment in model year 2008 and 2016 new vehicles[216]

Technology	Companies with technology in 2008	Companies with technology in 2016
Variable valve lift	4 (BMW, Honda, Subaru, VW)	7 (BMW, FCA, General Motors, Honda, Nissan, Toyota, VW)
Direct injection	7 (BMW, Daimler, General Motors, Honda, Mazda, Toyota, VW)	14 (BMW, Daimler, FCA, Ford, General Motors, Honda, Hyundai Kia, JLR, Mazda, Nissan, Subaru, Toyota, Volvo, VW)
Turbocharging	4 (Ford, General Motors, JLR, VW)	13 (BMW, Daimler, FCA, Ford, General Motors, Honda, Hyundai Kia, JLR, Nissan, Subaru, Toyota, Volvo, VW)
Cooled EGR	-	4 (FCA, Mazda, Nissan, Subaru)
Cylinder deactivation	3 (FCA, General Motors, Honda)	4 (FCA, General Motors, Honda, VW)
High-compression ratio	-	6 (Ford, General Motors, Hyundai Kia, Mazda, Nissan, Toyota)
Mild hybrid (Stop-start or integrated starter generator)	1 (Honda)	10 (BMW, Daimler, FCA, Ford, General Motors, Honda, JLR, Nissan, Volvo, VW)
Full hybrid	1 (Toyota)	7 (Ford, General Motors, Honda, Hyundai Kia, Nissan, Subaru, Toyota, VW)
8-speed transmission	1 (Toyota)	7 (BMW, FCA, Hyundai Kia, JLR, Toyota, Volvo, VW)
9-speed transmission	-	4 (Daimler, FCA, Honda, JLR)
Total companies with above technologies	21	77

Based on agencies baseline data from original 2012-2026 rulemaking and latest 2020-2026 rulemaking

Along with the multitude of examples in Table 3, the decision by Toyota to switch to HCR engines discussed above is a particularly noteworthy example that illustrates the faulty agency logic in subjectively deciding to constrain manufacturer options. In the draft TAR, the agency manufacturer constraints indicated that Toyota would move primarily to turbocharged engines by 2025, with 0% share of HCR engines.[217] However, by model year 2016, just one year after the TAR model baseline, Toyota had a fleetwide Atkinson naturally-aspirated engine penetration of 20.5% and started a later-realized switch to HCR on the high volume non-hybrid 2018 Camry.[218] The CAFE model for the draft TAR employed the same kind of general technology constraint as the current CAFE model, and the draft TAR disallowed HCR use for Toyota through 2025, while in the real world the cost-effective technology was already substantially deployed in 2018. To their credit, the 2018 NPRM removes the constraint on Toyota, and the

[216] *Datafiles from National Highway Safety Traffic Administration, 2018, "Compliance and Effects Modeling System." https://www.nhtsa.gov/corporate-average-fuel-economy/compliance-and-effects-modeling-system, and datafiles from U.S. EPA original 2017-2025 rulemaking https://www.epa.gov/regulations-emissions-vehicles-and-engines/final-rule-model-year-2017-and-later-light-duty-vehicle*

[217] *"Technology Utilization report" in output datafailes from 2016 Draft TAR "Compliance and Effects Modeling System." National Highway Safety Traffic Administration, 2018, "Compliance and Effects Modeling System." https://www.nhtsa.gov/corporate-average-fuel-economy/compliance-and-effects-modeling-system*

[218] *Input datafiles from National Highway Safety Traffic Administration, 2018, "Compliance and Effects Modeling System." https://www.nhtsa.gov/corporate-average-fuel-economy/compliance-and-effects-modeling-system*

modeling predicts nearly 64% HCR penetration for Toyota by 2025. Nonetheless, in a single year's time, Toyota's technology choices demonstrated that NHTSA's modeling constraints are incorrect and unfounded for all other automakers as well, yet those constraints remain in the model. The Toyota example demonstrates that it is invalid to assume that because a technology—in this case, HCR—is not deployed by a manufacturer in a specific year, it cannot or will not be deployed by that manufacturer going forward. Yet the agencies have hard-wired the model to prevent other automakers from utilizing HCR technology during the analysis period because they are not using it in 2016.

Essentially, the agencies' modeling approach with manufacturer-specific constraints ignores this overwhelming recent history, including this especially pointed Toyota example, and perpetuates the same kind of unfounded modeling constraints in the NPRM. Any time that the agencies constrain the adoption of cost-effective technology by 2025—as the NHTSA CAFE modeling system does for dozens for technology cases through its manufacturer constraints and the fixed technology paths—they are creating a false model that artificially props up and inflates their estimated modeled compliance cost. The recent historical data, with many of the exact same technologies and other incremental next steps of those technologies that are already emerging with various automakers (as discussed above), clearly shows that the agencies cannot reasonably justify their manufacturer-specific constraints or their rigid technology pathways that restrict baseline makes and models from being able to embrace new technologies. If the agencies continue to use these constraints, they have to justify specifically, company-by-company, why each automaker physically cannot adopt existing cost-effective technologies (rather than their current opposite approach that fixes companies' products to a more limited technology path, based on the baseline 2016 technology)

The agencies, based on their own extensive data on company technology deployment (e.g., the data shown in Table 2), ignore or dismiss these examples. Toyota's HCR switch appears to be the most glaringly incorrect modeling decision illustrating how invalid the model's logic is, but it is not the only one. The agencies' artificial technology constraints prevent 10 companies (BMW, Daimler, FCA, Ford, GM, Honda, JLR, Subaru, Volvo, and VW) from utilizing HCR technology on all their non-hybrid models (8 of these are prevented on all models including hybrids), even though the agencies estimate HCR is highly cost-effective and already projected by the model to be in use by 6 companies by 2025.[219] This fails to acknowledge how a competitive auto industry works and how competitive suppliers strive to achieve the same or greater efficiency at lower costs. This constraint also is not supported by the recent historical record. These examples -- based on the agencies' own data -- show how the agencies are using artificial manufacturer-driven constraints that do not stand the test of how the automotive industry works. Continued use of manufacturer-specific technology constraints for any of the above discussed technologies is unsupportable, as suppliers and automakers have the full capacity to deploy these technologies within the nine years from model year 2016 to 2025.

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[219] *Output datafiles from National Highway Safety Traffic Administration, 2018, "Compliance and Effects Modeling System." https://www.nhtsa.gov/corporate-average-fuel-economy/compliance-and-effects-modeling-system*

The agencies' modeling constraints are thus inconsistent with their own engineering data and compliance data. The only other explanation we can think of is that the automakers are supplying false or incomplete information that is unduly restrictive in saying which technologies can be deployed by 2025. As illustrated by Table 3 above, automakers have a tremendous ability to adopt technologies – even technologies that are not on their current models or anywhere within their full U.S. sales fleet – within 8 years of lead time. If the automakers are indicating they cannot adopt technologies by 2025 that are available in 2016-2018 by other automakers, the historical record clearly indicates otherwise for a wide variety of technologies across most companies.

Beyond the company-specific constraints, the agencies' compliance model also artificially constrains automakers by blocking the availability of known technology on a fleet-wide basis. Table 4 lists technologies that are already in production or for which production plans have been announced that are not allowed in the agencies' modeling, as well as technologies that are severely limited in application by the model. We make several observations based on our analysis of the agencies' constraints and technology omissions as compared to the automakers' actual technology developments.

Table 4. Summary of technologies, NPRM model technology constraints, and notes about production

Technology	In NRPM	NPRM discussion	Production & comments
Miller Cycle	No	"These engines may be considered in the analysis supporting the final rule, but these engine maps were not available in time for the NPRM analysis."	**Included in TAR** 2017 Audi A4, 2018 VW Tiguan 2017 Mazda
E-boost	No		Audi 2017 SQ7 diesel Mercedes 2019 AMG CLS53
CEGR2	No	Removed because 27-bar turbos also removed	**Included in TAR**
HCCI	No	Not included "primarily because effectiveness, cost, and mass market implementation readiness data are not available"	2019 Mazda SPCCI
Beltless CVT	No	"This technology may be commercially available as early as 2020."	
Variable compression ratio	No	"VCR technology appear to be at a production-intent stage of development, but also appear to be targeted primarily towards limited production, high performance and very high BMEP (27-30 bar) applications."	2019 Infinity QX50 2019 Nissan Altima
HCR2	No, only HCR1 and IACC are allowed	EPA's future engine concept "remains entirely speculative", as it has never been commercially produced and the engine map has not been validated even on a prototype level. "The CAFE model allows for incremental improvement over existing HCR1 technologies with the addition of improved accessory devices (IACC)"	**HCR2 included in TAR** 2018 Camry improves on HCR1 with not just IACC, but cooled EGR, fast warmup, low friction LUB, improved cam phasing, and engine friction reduction. ICCT tech brief showed techs exceeded EPA's efficiency projections
Cylinder deactivation	Limited to base engines	Modeling outputs show it cannot be combined with HCR or turbocharging	Multiple production models from GM, VW, and Mazda already combine turbocharging and cylinder deactivation
DCT	Limited to existing applications (3% of fleet)	"Today's analysis limits the application of improved DCTs to vehicles that already use DCTs."	DCT transmissions are more efficient and early drivability problems have been solved
CEGR1	Limited to TURBO2 engines	Technology pathways only allow CEGR to be added to TURBO2	2018 Camry uses cooled EGR on naturally aspirated engine. (no turbocharging) Some TURBO1 engines use CEGR (ex: 2016 Mazda turbo)
VVL	Modeling constraints limit application	52% share in augural case	The model forces 55% hybrids into the fleet before maximizing the use of low-cost conventional technologies. This is unrealistic
GDI		92% share in augural case	
TURBO2		8% TURBO1 share in augural case	
Advanced engines		10% of engines use neither HCR nor turbocharging in augural case	
Level 2 transmissions		18% of transmissions do not include level 2 improved efficiency	

What is especially befuddling is that the agencies included advanced cylinder deactivation in their modeling yet still constrained it from being used for compliance. As noted above, the

agencies' modeling outputs show it cannot be combined with HCR or turbocharging. In addition, they stated "[t]oday's analysis relied on CBI to estimate costs and effectiveness values of ADEAC. Since no engine map was available at the time of the NPRM analysis, ADEAC was estimated to improve a basic engine with VVL, VVT, SGDI, and DEAC by three percent (for 4 cylinder engines) six percent (for engines with more than 4 cylinders)."[220] If reasonable estimates could be made for ADEAC without fully validated engine maps, there is no reason to exclude other technologies on these grounds, especially considering the deep expertise by the agencies and their state-of-the-art technology simulation capabilities with the ALPHA modeling.

One major example is HCR level 2 (HCR2). Despite the facts that (as discussed above) the agencies have cost and effectiveness data for this technology, many automakers are already deploying the HCR1 technology, and the 2018 Camry has already put most of the HCR2 technologies into production, the agencies did not allow any application of HCR2 by 2025. Suggesting that HCR technology will not improve belies how technology innovation occurs and its use proliferates across the industry. Just as advanced cylinder deactivation and turbocharging technologies are emerging, next-generation level 2 HCR engines will also emerge. Because the agencies have access to data on higher compression ratio engines[221,222], it is readily feasible to make it available fleetwide in the timeframe of the rulemaking.

As discussed above, other omissions for technologies that are already in production, or for which production plans have been announced, are Miller cycle, E-boost, improved cooled EGR (CEGR2), gasoline homogeneous charge compression ignition (HCCI), and variable compression ratio (VCR). Miller cycle, E-boost and CEGR2 are well known and understood technologies that have been extensively modelled, including in the TAR, and are already in production. There is no justifiable reason to exclude these technologies. HCCI will be on a production vehicle in 2019, and is a potentially groundbreaking technology with major efficiency benefits that should not be ignored. Nissan's version of VCR is a Nissan exclusive technology for the foreseeable future, but Nissan clearly has substantial plans for this engine that should be included in the agencies' compliance modeling.[223] Further information on these viable technologies that have planned introductions are mentioned above. Again, the only explanations we can surmise for the agencies' system of omissions and constraints are that the agencies have biased the analysis against including all the viable technologies by inserting their own artificial constraints (either for lack of research, lack of analytical effort, or not fully utilizing all

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220 *83 Fed. Reg. at 43039*

221 *Wililam Charmley, 2018. Presentation to National Academies of Science Committee on the Assessment of Technologies for Improving Fuel Economy of Light-Duty Vehicles – Phase 3. http://sites.nationalacademies.org/cs/groups/depssite/documents/webpage/deps_188071.pptx*

222 *Ellies, B., Schenk, C., and Dekraker, P.,"Benchmarking and Hardware-in-the-Loop Operation of a 2014 MAZDA SkyActiv 2.0L 13:1 Compression Ratio Engine," SAE Technical Paper 2016–01–1007, 2016. Available at https://www.sae.org/publications/technical-papers/content/2016-01-1007/ and Lee, S., Schenk, C., and McDonald, J., "Air Flow Optimization and Calibration in High-Compression-Ratio Naturally Aspirated SI Engines with Cooled-EGR," SAE Technical Paper 2016–01–0565, 2016. Available at https://www.sae.org/publications/technical-papers/content/2016-01-0565/*

223 *"Nissan variable-compression engine gets first shot at volume with new 2019 Altima." Automotive Engineering. March 29, 2018. https://www.sae.org/news/2018/03/2019-nissan-altima-new-york-auto-show-reveal*

the agencies' best analytical tools and data) or that the auto industry is providing information that erroneously suggests their innovation is far less than what is demonstrated both above and in the agencies' own previous analyses.

An HCR2 sensitivity analysis conducted by the agencies illustrates how sensitive overall costs of compliance are to the artificial restrictions on technology in the NPRM. Simply making HCR2 available reduced the cost of complying with the Augural standards in 2025 by over $610, or nearly one third of the central case of $1,908, even with all the other unreasonable modeling constraints and algorithms in place.[224] This sensitivity run validates that modeling inputs for HCR2 have been fully developed and that it is a cost-effective technology, but the agencies have invalidly and artificially constrained it from being used in the primary regulatory assessment as described above.

This sensitivity of overall costs to restrictions on conventional technology is important in other ways. As noted above, the agencies' modeling for the augural case does not come close to maximizing the use of low-cost conventional technology. 48% of the fleet does not use variable valve lift (VVL), 8% does not use gasoline direct injection (GDI), 8% of the fleet uses basic TURBO1 systems instead of upgrading to TURBO2, 10% of engines are not upgraded to either HCR or turbocharging, and 18% of the fleet does is not upgraded to level 2 transmission efficiencies.[225] These technology limitations constrain the ability of manufacturers to meet the augural standards and force the model to add very expensive hybrid systems (32% BISG and 22% full hybrids) instead.[226]

3. *Technology combination constraints*

In the development of the pathways, the agencies have made many systematic errors that artificially and falsely constrain the availability of technologies based on subjective decisions on allowed technology packages. The agencies' primary flaw is to constrain technologies and technology paths according to the original baseline technologies used on each engine, transmission and platform. When the agencies affix baseline powertrains (e.g., turbocharged baseline vehicles are irrevocably committed to the agencies' turbo path) they are artificially constraining powertrains for nine years. This is a common problem that pervades the agencies' CAFE modeling approach. This problem is compounded because the agencies layer on additional constraints due to its subjective and false constraints on the *combinations* of technologies allowed in each pathway.

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[224] *HCR2 sensitivity analysis "Compliance report" output datafile and standard-setting "compliance report" output datafile from National Highway Safety Traffic Administration, 2018, "Compliance and Effects Modeling System." https://www.nhtsa.gov/corporate-average-fuel-economy/compliance-and-effects-modeling-system*

[225] *Standard-setting "technology utilization report" output datafile from National Highway Safety Traffic Administration, 2018, "Compliance and Effects Modeling System." https://www.nhtsa.gov/corporate-average-fuel-economy/compliance-and-effects-modeling-system*

[226] *Standard-setting "technology utilization report" output datafile from National Highway Safety Traffic Administration, 2018, "Compliance and Effects Modeling System." https://www.nhtsa.gov/corporate-average-fuel-economy/compliance-and-effects-modeling-system*

There are many specific cases where viable technology combinations are not allowed. This demonstrates the existence of illogical technology steps and pathway constraints that clearly would not be allowed if the agencies had properly built their model based on what is happening in the auto industry. For example, turbocharging and cylinder deactivation (DEAC) are treated as mutually exclusive by the agencies, as are HCR1 and DEAC.[227] However, as acknowledged by the agencies, these technology combinations are technically viable. Volkswagen's most recent EA211 engine has both cylinder deactivation and uses the Miller cycle, which is, essentially, a turbocharged HCR engine.[228] Mazda also now uses cylinder deactivation on its SkyActiv 2.5L engine, which, again, uses a high compression ratio.[229] These real world examples demonstrate the absurdity of the agencies' constraints.

An even more basic example of arbitrary limitations on technology packages is that the model prohibits the use of cooled EGR on naturally aspirated engines.[230] The model only permits this technology as the final step on the turbo pathway. This constraint is again belied by existing, real-world technology. As described above, the model year 2018 naturally aspirated Toyota Camry uses cooled EGR (and high compression ratio) and shows on-the-ground efficiency improvement beyond the HCR1 engine. Given this real-world, tested application of cooled EGR (CEGR1) to a naturally aspirated engine, the model's prohibition on applying CEGR1 to naturally aspirated engines is another unreasonable and unjustified constraint.

The agencies' primary way to implement these package constraints appears to be by obscuring the arbitrary and unrealistic constraints in pre-determined technology paths. In other words, the agencies have – without basis in the real world – simply made certain technologies unavailable within certain pathways, such that, for example, a vehicle within the HCR pathway cannot adopt CEGR1, but a vehicle within the turbocharging pathway can.[231]

To recognize the actual automotive technology developments that are occurring, the agencies would need to remove these artificial constraints and allow all the above mentioned technology combinations (Turbo-DEAC; HCR1-DEAC; HCR-CEGR1) to be utilized by *every* manufacturer if and when they are cost-effective. In addition, as mentioned below in the cost section, there are many further turbocharging combinations that are erroneously not included in the analysis, including adding the Miller cycle for an additional 4%-5% benefit; axial flow turbines and variable geometry turbos for 1-2% benefit; and e-boosting for a 2%-5% benefit (greater if coupled with a 48-volt mild hybrid system).[232] Not including all these combinations as options on the technology

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[227] *PRIA section 6.4.2.4.2 at 491, and Figure 6-181*

[228] Again, all of this information has already been documented y EPA and informed its determination that the 2025 standards remain appropriate under the Clean Air Act. See Proposed Determination Technical Support Document at 2-309.

[229] *2018 Mazda CX-5 specifications at 2. https://www.mazdausa.com/siteassets/pdf/features--specs/2018/cx-5/2018_mazda_cx5_features_specs.pdf*

[230] *PRIA Figure 6-181 shows CEGR is only on the Turbo Engine Path, which is exclusive of all other advanced engine paths (including HCR and ADEAC), p. 491.*

[231] *Ibid.*

[232] *Aaron Isenstadt and John German (ICCT); Mihai Dorobantu (Eaton); David Boggs (Ricardo); Tom Watson (JCI). Downsized boosted gasoline engines, October 28, 2016. http://www.theicct.org/downsized-boosted-gasoline-engines*

paths for all automakers by 2025 would amount to a false agency modeling constraint that artificially inflates their estimated compliance costs.

Further, in order to enable meaningful public comment, these technology combination and pathway constraints must be explicitly documented and justified, which they are not. Until the agencies justify each and every constraint they impose on a company, technology, and technology combination basis, the agencies must remove their manufacturer and model-specific technology-sequencing and technology-combination based constraints in their modeling framework. This is necessary in order to have a credible and transparent regulatory assessment that does not obscure any possibly biased decisions by agency modelers. The agencies should provide this critical information and provide an additional public comment opportunity.

4. Failure to consider cost-effectiveness when adding technologies

In the construction of packages for the technology sequencing, the agencies have made systematic errors that do not reflect realistic automaker decisions on adoption of technologies to comply with the CAFE and GHG standards. Table 5 summarizes specific technology examples that demonstrate a deeply flawed logic with nearly no quality control steps to ensure realistic sequencing of technology adoption that reflects best available data on technology costs and effectiveness.

Examination of the modeling code and outputs suggests that part of the Volpe CAFE problem is the mutually exclusive path design that allows for no "off ramps" as standards increase in stringency, as described above. Moreover, once you're on a path, you're forced to walk through what the CAFE modelers have determined as the path for each starting point. A consequence of this is the model may not select the most optimal technologies, since its pathways are fixed. Another issue is that technologies are not applied to a vehicle based solely on cost-effectiveness (cost per fuel consumption or GHG improvement). Rather, technologies are applied based on a calculation that considers all vehicles applying that technology or combination in a manufacturer's fleet.[233] The result is that changing input parameters for one vehicle, engine, platform, or vehicle type affects the entire model output. We list several examples from our analysis that show how the agencies' CAFE model is working to cause this effect, based on its inputs and algorithms.

Cooled exhaust gas recirculation. CEGR1 added to TURBO2 has 0.0% effectiveness with $359 cost in 2025, as falsely modeled in the agencies' data files. This, according to the agencies' modeled assumptions, is not an attractive technology, yet for the Augural case the CAFE model forces it on 38% of the fleet. When we blocked the adoption of CEGR1, it reduced the 2025 Augural standards cost of compliance by $116. This is a ridiculous result, as removing technology choices should never reduce the cost of compliance, and it reveals a CAFE

[233] *Model Documentation for 2018 NPRM at equation 45 in section 5.3.2, https://www.nhtsa.gov/corporate-average-fuel-economy/compliance-and-effects-modeling-system#compliance-and-effects-modeling-system-downloads*

modeling approach that is poorly vetted and fails at its sole purpose of projecting auto companies' future cost-effective technology approaches.

Stop-start 12-volt. The agencies assume SS12V has direct manufacturing costs of $403-$498 for just a sales-weighted average reduction in fuel consumption of 1%.[234] EPA's Proposed and Final Determinations' analyses appropriately find SS12V costs nearly $100 less with 3-4% benefit.[235] Unfortunately, evaluating the impact of these erroneous assumptions regarding 12VSS on the total cost of compliance is more difficult than it is for CEGR1. CEGR1 is at the end of a technology pathway, so blocking the technology has no impact on other technologies. However, 12VSS is at the beginning of the electrification pathway, so simply blocking 12VSS would reduce the cost of BISG hybrids, as the model adds the incremental cost of BISG over 12VSS. Thus, we were not able to definitively assess the impact of including 12VSS in the model. Nevertheless, the fact that SS12V is not as cost effective as other technologies in the chain suggests that it likewise causes an unrealistic increase in compliance costs. BISG is an example of a technology that comes after SS12V in the agencies technology sequence even though it appears to be more much more cost-effective. The agencies assume BISG has direct manufacturing costs of $1,459–$1,710, incremental to a baseline vehicle with no electrical improvements or electrification.[236] With all the same assumptions used to estimate average SS12V effectiveness, the agencies' data indicates that BISG has a sales-weighted average reduction in fuel consumption of 5.3%.[237] Thus, BISG has an estimated cost-effectiveness of $275–$322 per percent reduction in fuel consumption, whereas SS12V has a cost-effectiveness of $403–$498 per percent reduction in fuel consumption. Reasonable modeling for fleet compliance (by agencies, or in the real-world by automakers) would do a better job at selecting technologies according to their cost-effectiveness.

Improved turbocharging (TURBO2). The modeled benefits of TURBO2 over TURBO1 vary widely, depending on the vehicle class and technology combination. EPA graphed the incremental benefit of TURBO2 over TURBO1 for the CAFE modeling and found many instances where the benefits were negative (Figure 2).[238] For the combination using the highest volume technologies from the augural standard run, with AT10L2 transmissions, all of the vehicle classes had a benefit of at least 0.7%. Given the high incremental cost of TURBO2, $446, it is likely that TURBO2 is cost-effective for some vehicle classes but not others.

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[234] *This is the sales-weighted average across vehicle classes, when the most popular technologies in 2025 (CEGR1, AT10L2, EPS, IACC, ELEC, LDB, ROLL20, MR4, AERO20) are included with and without stop-start technology. "ELEC" may be "CONV" or "SS12V". These are based on the datafiles of the agencies at National Highway Safety Traffic Administration, 2018, "Compliance and Effects Modeling System." https://www.nhtsa.gov/corporate-average-fuel-economy/compliance-and-effects-modeling-system.*

[235] *EPA Proposed Determination Technical Support Document at Tables 2.88 and 2.89, p. 2-336*

[236] *PRIA Table 9-3*

[237] *This is the sales-weighted average across vehicle classes, when the most popular technologies in 2025 (CEGR1, AT10L2, EPS, IACC, ELEC, LDB, ROLL20, MR4, AERO20) are included with and without BISG technology. "ELEC" may be "CONV" or "BISG". These are based on the datafiles of the agencies at National Highway Safety Traffic Administration, 2018, "Compliance and Effects Modeling System." https://www.nhtsa.gov/corporate-average-fuel-economy/compliance-and-effects-modeling-system.*

[238] *Email 5 - Email from William Charmley to Chandana Achanta - June 18, 2018" and is available at: https://www.regulations.gov/document?D=EPA-HQ-OAR-2018-0283-0453*

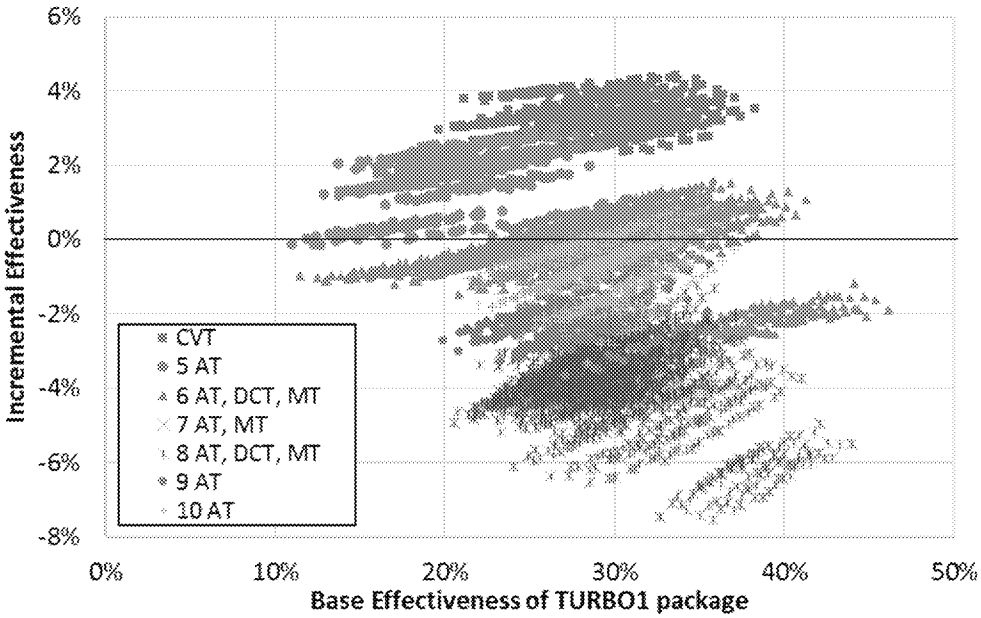

Figure 2. Incremental effectiveness of TURBO2 on a medium-sized performance SUV plotted for various transmission packages.

This is another example of obvious errors in ANL modeling, which is exacerbated by CAFE's unreasonable modeling constraints, It is unsupportable both that the incremental benefit of TURBO2 over TURBO1 should vary by 10% depending on the baseline vehicle model and technology, and that the technology would be added despite sometimes having a *negative* incremental benefit. The Volpe CAFE model appears to compound the ANL modeling problem by adding TURBO2 for scenarios where the cost-effectiveness is very poor due to the high cost of the technology. This is another illustration that the Volpe CAFE model is adding technologies without first checking to assure they are cost-effective.

10-speed transmissions, DCTs, EPS. The impacts of the other technologies listed in Table 5 are small. As described above, AT10L2 is erroneously modeled as being less effective than AT6L2 in many technology combinations.[239] Moreover, although AT10L2 is also slightly cheaper than AT6L2 (although this makes no sense) and so the modeled cost-effectiveness is almost as good as the AT6L2 despite having lower efficiency, AT10L2 is nevertheless less cost effective than AT6L2. Thus, the shift from AT6L2 to AT10L2 adds cost while reducing both overall effectiveness and cost-effectiveness - thus, it should *never* be adopted as modeled. Yet, as described above, AT10L2 is projected to be adopted by a significant portion of the fleet (more than 30%). Similarly, DCT8 transmissions carry a direct manufacturing cost of $349 more than

[239] *PRIA Figure 6-151. The effectiveness of AT10L2 vs AT6L2 can also be seen by comparing the fuel consumption improvement values of AT10L2 and AT6L2 (with other technologies held constant) within the ANL database "FC1_Improvements.csv" (contained within the CAFE model source code and viewable through the CAFE model user interface), which serves as an input into the CAFE model.*

DCT6 but actually reduce efficiency over DCT6.[240] Although their market penetration was restricted to 1.2% of the fleet, and so the impact in 2025 is less than $10 per vehicle, the fact is these transmissions should *never* be applied if they have negative effectiveness. Yet the model does apply it. And Electric power steering (EPS) likewise has no benefit for the augural case scenario and costs $94.[241] It is already used on 88% of the baseline 2016 fleet, so the incremental impact on 2025 compliance is only about $13. But, again, a rational model would never apply this technology modeled to have *zero* benefit. Yet, again, the model irrationally applies it anyway.

Regardless of the impact on total costs, inclusion of technologies with little, no, or negative efficiency benefits does not make any sense and illustrates two separate problems with the NPRM modeling. The ANL simulations, on which the efficiency benefits are based, cannot be accurate. The benefits of TURBO2 engines, cooled EGR, 10-speed automatic transmissions, 8-speed DCT, electric power steering, and stop-start systems are well established. This is supported by the rapid adoption of these technologies by manufacturers, who would not use them if they did not have significant efficiency benefits. These estimates by ANL can only be the result of major problems with their modeling. In addition, it shows that the Volpe model is not even assessing the cost-benefit of adding incremental technologies, much less using incremental cost-benefit as the basis of adding technologies. If something so basic as preventing the addition of technologies with little or even negative benefit is not being done, it suggests that there is little or no optimization of costs in the Volpe model. And given that projecting cost-effective compliance pathways is the model's sole purpose, it is evident that the model fails in that purpose.

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[240] *Transmission direct manufacturing costs from PRIA Table 9-2. Transmission effectiveness estimated in two ways: (1) by comparing the fuel consumption improvement values of DCT8 and DCT6 (with other technologies held constant) within the ANL database "FC1_Improvements.csv" (contained within the CAFE model source code and viewable through the CAFE model user interface), which serves as an input into the CAFE model; (2) using the sales-weighted average across vehicle classes, when the most popular technologies in 2025 (CEGR1, TRANS, EPS, IACC, BISG, LDB, ROLL20, MR4, AERO20) are included with and without DCT8 technology. "TRANS" may be "DCT6" or "DCT8". These are based on the datafiles of the agencies at National Highway Safety Traffic Administration, 2018, "Compliance and Effects Modeling System." https://www.nhtsa.gov/corporate-average-fuel-economy/compliance-and-effects-modeling-system.*

[241] *Direct manufacturing costs from PRIA Table 9-3. Effectiveness is based on the sales-weighted average across vehicle classes, when the most popular technologies in 2025 (CEGR1, AT10L2, EPS, IACC, BISG, LDB, ROLL20, MR4, AERO20) are included with and without EPS technology. These are based on the datafiles of the agencies at National Highway Safety Traffic Administration, 2018, "Compliance and Effects Modeling System." https://www.nhtsa.gov/corporate-average-fuel-economy/compliance-and-effects-modeling-system.*

Table 5. Addition of technologies with little or no efficiency benefit.

NPRM Volpe model using highest volume technologies from augural run (CEGR1, AT10L2, EPS, IACC, BISG, LDB, ROLL20, MR4, AERO20)				
Technology	Compared to	MPG benefit	2025 Cost increment	Technology penetration
TURBO2	TURBO1	Varies by vehicle type 0.7% to 6.5%	$446	55%
CEGR1	TURBO2	0.0%	$359	37.7%
AT10L2	AT6L2	(0.5%)*	($13)	33.2%
DCT8	DCT6	(1.9%)*	$545	1.2%
EPS	--	0.0%	$112	99.9%
SS12V	No electrification	1.0%*	$509	14.1%

* sales-weighted average

5. Recommendation for agencies' retrospective review

We urge that the agencies must examine efficiency technology retrospectively with an aim to improve their manufacturer-based logic in the CAFE model. The agencies have inserted many constraints in their modeling that bind automakers in 2025 to the technologies (and technology pathways) that are in their baseline 2016 fleets. This incorporates a narrow and unfounded approach that ignores the historical record regarding how the industry adopts technologies over a nine-year period. It appears clear from the turbocharging example how restrictive the agencies' approach has been. As discussed above, in 2016, BMW, Daimler, Fiat-Chrysler, Ford, General Motors, Honda, Hyundai-Kia, JLR, Mazda, Nissan, Subaru, Toyota, Volkswagen, and Volvo have many models with turbocharging; however, these companies had very few such models with turbocharging in model year 2007, nine years previous. The agencies' restriction on all technologies to existing 2016 baseline adoption (including turbocharging, CEGR, cylinder deactivation, HCR) shows that the agencies have failed to fully utilize the historical EPA data[242] at their disposal to develop a more rigorous method for how technology adoption really occurs across companies.

As a result, based on a retrospective view on how turbocharging has been widely deployed, we make the general recommendation that the agencies' modeling allow all companies to adopt any combinations of turbocharging, CEGR, and HCR technologies by 2025, regardless of their baseline 2016 technology adoption. Without such a change, the agencies are falsely and unreasonably constraining realistic cost-effective scenarios in their rulemaking assessment. This would reflect what is happening in the fleet in 2016-2018, and it also reflects how automaker- and supplier-developed technologies each have the ability to migrate across all companies over a 9-year span. We recommend all necessary underlying corrections within the CAFE modeling to ensure that this more realistic and less-restrictive technology adoption is allowed.

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[242] *Environmental Protection Agency. The Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends Report. https://www.epa.gov/fuel-economy-trends*

Overall, there are many cases identified above where the approach used to impose constraints on deployment or migration of technology across the fleet is improperly restricted, contrary to recent evidence of industry practice as well as contrary to the competitive and other factors that clearly support the expectation of continued and further migrations of technologies as developments are made by suppliers and manufacturers. However, the objections to the artificial technology migration constraints employed in the CAFE modeling are not limited to these many specific instances. The basic approach underlying such constraints appears to be subjective in nature, and is not based on a clear and transparent analysis of data and evidence. The agencies must reject this approach. They need to identify each and every technology constraint imposed in their modeling, and provide a clear engineering and evidence based justification for each such constraint. Absent such a justification, the default assumption must be that the industry and the competitive market will make decisions based on cost and effectiveness alone, and the CAFE modeling should impose no additional constraint other than to seek the minimum cost compliance solution among available technologies. As described in detail above, the model currently fails entirely to do so.

Unless or until there is a systematic vetting of the agencies new system IAV-Autonomie-CAFE modeling (including fixes identified in these comments), the previous approach using EPA's engine maps ALPHA and OMEGA modeling seems vastly superior as a reliable framework to assess the impacts of the regulation. At a minimum, the agencies must also include modeling using EPA's OMEGA and ALPHA models, and not just CAFE and Autonomie modeling, to help avoid the inappropriate elements of the CAFE modeling described above.

Due to our findings regarding the agencies' incomplete analysis of existing technologies that are on production vehicles, we ask that the agencies do a complete update of their reference dataset to model year 2017. The model year 2017 dataset, including each model's sales, fuel economy, CO_2 emission rates, footprint, and the associated efficiency technologies is in the possession of the agencies due to EPA's data-collection and enforcement responsibilities. The examples we discuss in our comments where the agencies are failing to acknowledge in factual terms what technologies the auto industry is deploying make it necessary that the agencies update their initial reference dataset, re-examine every technology that is on those vehicles, and use the updated 2017 dataset as the new basis for their future year compliance scenarios. This update and sharing the 2017 dataset at a make and model level will ensure the agencies compliance modeling is predicated on up-to-date data and the agencies are not neglecting real-world trends, as with the examples we are sharing in these comments (e.g., related to HCR).

We ask that, based on this update for a complete 2017 dataset, the agencies also provide a rigorous summary table that includes, for each significant efficiency technology used to comply with the adopted and augural future standards, the model year 2010, 2016, and 2017 sales and sales shares of those technologies. We also recommend that the agencies show the percent increase from 2010 to 2017, and from 2016 to 2017 for each technology, to show that the technologies (some of which they are constraining from use in their modeling) are being deployed in increasing numbers in the marketplace. We also ask the agencies to disclose the efficiency technologies that the automakers have disclosed will be on production vehicles by

2025 (without naming automaker names, to avoid disclosing confidential business information). If the agencies do not do this, it would appear (based on our analysis of auto industry announcements) that the agencies are not fully disclosing information in their possession that is contrary to their own subjective technology constraints.

We conclude by pointing out there are many flaws that EPA pointed out to NHTSA, but these flaws have not, apparently, been constructively responded to or resolved. EPA identified numerous flaws and problems with the CAFE model, including problems that are new since the Draft TAR.[243,244] Based on this, the OMEGA model is preferable, since it does not suffer from these issues, and has been more thoroughly vetted for these exact issues. EPA's OMEGA and NHTSA's Volpe differ in redesign and refresh rates. However, based on extensive analysis with and adjustments with the various model inputs and methodologies, EPA concludes that it is not the difference in redesign frequency in OMEGA versus Volpe that generates the large differences in compliance costs. Rather, it is more fundamental differences in inputs, constraints, and anomalies within the CAFE model that are driving its high costs.[245] This is fully consistent with our own independent analysis of the rulemaking data files, as indicated throughout these comments.

C. Technology cost and cost-effectiveness

The agencies failed to capture the latest available information and, as a result, their assessment incorrectly and artificially overstates technology costs. Based on our analysis of the NPRM and its supporting information, and on comparing it with best available information elsewhere, we point out several examples that illustrate how and where the agencies have failed to include the most accurate and updated information in their rulemaking. Note that, although the agencies handle costs in different ways at various stages in the rulemaking (e.g., total vs direct

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243 *"Email 5": Email_5_-_Email_from_William_Charmley_to_Chandana_Achanta_-_June_18,_2018. https://www.regulations.gov/document?D=EPA-HQ-OAR-2018-0283-0453. Page 11. "While the results of the EPA-Revised version of the CAFE model are now directionally closer to our previous work where we used our own tools and models for the 2012 FRM, 2016 DTAR, and 2016 Proposed Determination, we are not endorsing the use of our modified version of the CAFE model for use in policy setting for the GHG program, in part because of the range of issues we have previously identified with the modeling inputs and assumptions—such as unduly high battery costs, production-ready but unconsidered and/or overly constrained technologies and technology application processes, etc.—that are outside of the scope of this memo and are not addressed by the EPA-revised version of the CAFE model."*

244 *"Email 5": Email_5_-_Email_from_William_Charmley_to_Chandana_Achanta_-_June_18,_2018. https://www.regulations.gov/document?D=EPA-HQ-OAR-2018-0283-0453. Page 32. "although the "EPA Revised" version of the CAFE model has corrected some issues, there are still outstanding issues with this model. Thus we cannot endorse the use of our modified version of the CAFE model for use in policy setting for the GHG program. In part, this is because of the range of issues we have previously identified with the modeling inputs and assumptions—such as unduly high battery costs, production-ready but unconsidered and/or overly constrained technologies and technology application processes, etc.—that are outside of the scope of this memo and are not addressed by the EPA-revised version of the CAFE model."*

245 *"Email 5": Email_5_-_Email_from_William_Charmley_to_Chandana_Achanta_-_June_18,_2018. https://www.regulations.gov/document?D=EPA-HQ-OAR-2018-0283-0453. Page 108.*

manufacturing, and for different years), costs as used below are intended to show 2025 direct manufacturing costs, and incorporate manufacturer learning.

We note that because the agencies present cost data in so many different ways in dozens of different places in the NPRM, impact assessment, and supporting data files, the precise agencies' costs are obscured and not transparent. We have done our best to corroborate each agency cost below from at least two places in the agencies' documentation. This difficulty in understanding the costs was also shared by EPA staff, who were ostensibly involved in the analysis. As shared in interagency emails and posted in the rulemaking docket. "The *CAFE model vehicles_report* output file provides vehicle price increases, which in some cases is the same as the tech cost increase, and other cases significantly higher"[246] Without a clear explanation of the methodology, it is unclear precisely how price increases are determined, as well as the relationship between the technology costs, fines, and price increases. Regardless, based on the best available information, including the text and the input and output data files, we provide comments below on the agencies cost estimates.

1. Individual technologies

Direct injection. The agencies substantially overestimate cost of gasoline direct injection (GDI), a high-volume compliance technology in use by many automakers. They have not examined the most updated and applicable information. ICCT, together with FEV EU, specifically calculated updated costs for gasoline direct injection in 2016.[247] Their cost estimates were $28-$52 per cylinder. FEV's costs are scaled to V6 and V8 engines using FEV I3 cost divided by EPA's I3 cost. In contrast, the agencies estimated that GDI costs $59 per cylinder over variable valve timing (VVT) ($78 per bank). The ICCT and FEV figures are summarized Table 6, alongside our attempt to isolate the applicable GDI costs (total, and incremental costs to VVT). ICCT's and FEV's technology working paper found costs to be substantially lower than the agencies assessment, which did not reference the ICCT's and FEV's 2016-published work. For Table 6, note that I-configuration engines have one cylinder bank and V-configuration engines have two cylinder banks.

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[246] *"Email 5": Email_5_-_Email_from_William_Charmley_to_Chandana_Achanta_-_June_18,_2018. https://www.regulations.gov/document?D=EPA-HQ-OAR-2018-0283-0453. Page 51.*

[247] *David Blanco-Rodriguez, 2025 Passenger car and light commercial vehicle powertrain technology analysis. FEV GmbH. November 21, 2016. https://www.theicct.org/publications/2025-passenger-car-and-light-commercial-vehicle-powertrain-technology-analysis and Aaron Isenstadt and John German (ICCT); Mihai Dorobantu (Eaton); David Boggs (Ricardo); Tom Watson (JCI). Downsized boosted gasoline engines, October 28, 2016. http://www.theicct.org/downsized-boosted-gasoline-engines*

Table 6. Technology cost for direct injection

	Cost			
	I3	I4	V6	V8
Agency proposal (total)	$233	$287	$466	$573
Agency proposal (over VVT)	$162	$216	$323	$430
Updated data (ICCT, FEV)	$120	$160	$240	$320

Cooled exhaust gas recirculation. The agencies invalidly overestimate the costs of cooled exhaust gas recirculation (CEGR) for gasoline engines. As with direct injection, the agencies have not investigated or discussed the information ICCT previously published and shared on cooled EGR costs. FEV specifically calculated updated costs for gasoline CEGR.[248] They calculated a cost of $116 for inline engines (4-cylinder) and $149 for V engines (i.e., V-6 and V-8). The most updated costs, based on ICCT and FEV data, as compared to our best estimate of the comparable agencies' costs, are in Table 7. The agencies assumed CEGR applies as the last step in the turbocharged engine pathway, thus the costs are incremental to the penultimate turbo technology (TURBO2). Furthermore, as pointed out elsewhere in these comments, the FEV estimate of cooled EGR effectiveness is 2.5%, whereas the NPRM estimate is 0%. As a result, for CEGR, the agencies have artificially added a technology, which it falsely indicates has no benefit, and then artificially increased that technology costs, thus compounding multiple errors. As with all tables presented in this section, note that Table 7 shows direct manufacturing costs adjusted for manufacturer learning.[249] Elsewhere, we also cite the *total* cost of CEGR ($359), which includes the retail price equivalent markup.

Table 7. Technology cost for cooled EGR

	Cost by engine type	
	Inline	V
Agency proposal (over TURBO2)	$244	$244
Updated data (ICCT, FEV)	$116	$149

High compression ratio engines. In the case of HCR, in addition to the agencies' invalid decision to make HCR1 unavailable for most vehicles, they inappropriately increased HCR1 costs above what is indicated from best available data and the agencies' previous TAR analysis. Table 8 illustrates the agencies costs in comparison to more appropriate and up-to-date data. The agencies estimated the base cost of HCR1 at $550-$1,108 incremental over variable valve

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[248] *David Blanco-Rodriguez, 2025 Passenger car and light commercial vehicle powertrain technology analysis. FEV GmbH. November 21, 2016. https://www.theicct.org/publications/2025-passenger-car-and-light-commercial-vehicle-powertrain-technology-analysis and Aaron Isenstadt and John German (ICCT); Mihai Dorobantu (Eaton); David Boggs (Ricardo); Tom Watson (JCI). Downsized boosted gasoline engines, October 28, 2016. http://www.theicct.org/downsized-boosted-gasoline-engines*

[249] *Direct manufacturing costs are found PRIA Tables 9-1 through 9-9. Learning rates are found in PRIA Table 9-94*

timing (VVT).[250] Improvements due to learning over time reduces this to $402-$809 by 2025.[251] The Proposed Determination estimate for HCR costs, however, were $93-$222, incremental to GDI (see above costs) and VVT ($65-$139).[252] This is a clear case where the agencies appear to have not used the best available data from EPA which has extensively analyzed this technology and its associated cost, nor have the agencies justified how they have increased the associated costs, apparently by a factor of three. The agencies should reinstate the better justified and more deeply analyzed original Proposed Determination HCR cost numbers from EPA for this rulemaking.

Table 8. Technology cost on high-compression ratio engines, incremental to VVT

	Cost			
	I3	I4	V6	V8
Agency proposal (over VVT)	$408	$402	$592	$809
Original, appropriate EPA costs with GDI (over VVT)	$213	$253	$380	$542

Miller cycle for turbocharged engines. The Miller cycle, essentially Atkinson Cycle engine operation and technology, applied on a turbocharged engine, was not included in the model by the agencies. Most of the cost of the Atkinson engine (above) is due to increased scavenging to maintain performance and extend the efficiency region. However, for the Miller cycle, this performance function is duplicative of the 24-bar turbo system with a variable geometry turbocharger added in the Proposed Determination to maintain performance for the Miller cycle.[253] Thus, Atkinson cycle costs are valid for naturally aspirated engines but these costs should not be applied for the Miller cycle. Miller cycle is estimated to improve efficiency 4-5% over an already-turbocharged engine.[254] The agencies have erroneously excluded Miller cycle approach, and it should be reinstated as viable for all automakers that can use turbocharging or HCR technology, as the agencies own data reveals it be very cost-effective technology and is already in production (by Volkswagen and Mazda), as described above. This is another case where the agencies appear to have not used the best available data from EPA which has extensively analyzed this technology and its associated cost.

Advanced cylinder deactivation. The agencies estimated a greatly exaggerated cost of advanced cylinder deactivation for that level of the technology due to their lack of investigation into the necessary bottom-up technology costs. Table 9 compares the agencies' inappropriately

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[250] *PRIA Table 9-1*

[251] *PRIA Table 9-94*

[252] *VVT direct manufacturing costs are found PRIA Tables 9-1 through 9-9. Learning rates are found in PRIA Table 9-94*

[253] *Aaron Isenstadt and John German (ICCT); Mihai Dorobantu (Eaton); David Boggs (Ricardo); Tom Watson (JCI). Downsized boosted gasoline engines, October 28, 2016. http://www.theicct.org/downsized-boosted-gasoline-engines*

[254] *Id.*

high costs as compared to our costs from our working paper[255] (which was submitted in the Proposed Determination and not responded to). We find the appropriate advanced cylinder deactivation cost to be based on variable valve lift (VVL) technology of $121 for a 4-cylnder engine, plus an additional $32 for noise, vibration, and harshness (NVH) improvements. The agencies' previous Joint TSD for the 2012 rulemaking, p 3-81, states that engines equipped with "mechanisms required for cylinder deactivation" would only need this level of NVH. The rationale for especially high agency costs are unclear, but their costs appear to account for finger-follower de-lashing on a fixed block of cylinders (half the cylinders of a V6 or V8), which is not needed for dynamic cylinder deactivation.

Table 9. Technology cost and fuel consumption reduction for cylinder deactivation

	Cost			Fuel consumption reduction
	I4	V6	V8	
Agency advanced deactivation (over VVT)	$835	$1,253	$1,671	3% - 6%
Dynamic deactivation (ICCT, FEV)	$153	$248	$320	6.5% - 8.3%

These findings are corroborated by EPA's communications with NHTSA and other officials, as shared in interagency emails and posted in the rulemaking docket. EPA indicates that the agencies' assumed cost for ADEAC is 2 to 4 times the cost of industry-quoted costs for the version of the technology in production in MY2019.[256] This is troubling that the assumed agency cost would so wildly diverge from important information, and that the agencies would choose not to share this clearly applicable information other than buried in interagency dialogue.

Turbocharging. One of the more substantial technology areas that the agencies are incorrectly overestimating costs is in turbocharging packages. Advances in these technologies increasingly expand the efficiency frontier and make turbocharging more cost effective. Related to this, the agencies have overestimated the costs by hundreds of dollars per application of the turbocharging package.

First, a principle benefit of turbocharging is the capacity for engine downsizing, which can reduce the parts and complexity of the engine when cylinder count decreases. Downsizing reduces the cost of the turbocharger system and associated engine changes, especially when the number of cylinders can be reduced. This is demonstrated by the widespread substitution of 4-cylinder turbos for naturally aspirated V6 engines in the fleet. It appears that the agencies have not appropriately downsized the fleet to maintain constant vehicle utility and performance.

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[255] *Aaron Isenstadt and John German (ICCT), Mihai Dorobantu (Eaton). Naturally aspirated gasoline engines and cylinder deactivation, June 21, 2016. http://www.theicct.org/naturally-aspirated-gas-engines-201606 and David Blanco-Rodriguez, 2025 Passenger car and light commercial vehicle powertrain technology analysis. FEV GmbH. November 21, 2016. https://www.theicct.org/publications/2025-passenger-car-and-light-commercial-vehicle-powertrain-technology-analysis*

[256] *"Email 5": Email_5_-_Email_from_William_Charmley_to_Chandana_Achanta_-_June_18,_2018. https://www.regulations.gov/document?D=EPA-HQ-OAR-2018-0283-0453. Page 48. "The cost of ADEAC is 2-4 times higher than industry quoted costs for the version of the technology which is going into production in MY2019"*

Because there are many buried analytical assumptions, the agencies need to comprehensively report in their "vehicle report" file, the final engine displacement, the maximum power of each engine, the maximum torque of each engine, the initial and final curb weight of each vehicle (in absolute terms), and estimated 0-60 mph acceleration time of each model in their compliant Augural 2025 fleet, and then allow an additional public comment opportunity. Without showing this data, the agency is showing that they have not even attempted to accurately analyze the future year fleet for their performance. It also appears clear that the agencies are intentionally burying a critical assumption, whereby their future fleet has not been appropriately downsized, and it therefore has greatly increased utility and performance characteristics. Any buried increase in performance is an unaccounted for benefit of the standards and related inappropriate over counting of the compliance costs.

As previously determined by the agencies and the National Academy analysis, engineering teardown studies are the ideal basis for technology cost analysis.[257] Yet compared to FEV engineering teardown analyses[258] as well as EPA's detailed technology benchmarking analysis for the TSD and Proposed Determination, the agencies have greatly increased turbocharging costs. Based on the FEV teardown and EPA analysis, turbodownsizing costs for 18-bar turbocharging range from a -$391 (i.e., a benefit due to moving from 6 to 4 cylinders) to a cost increase of $376 (for shift from V8 to V6).[259] These, along with EPA's more rigorous assessments of 24-bar and CEGR technology from its original Proposed and Final Determination, are in Table 10.[260] As evident in the table, the latest agencies' cost estimates for turbo-downsizing are greatly exaggerated, and these differences are not substantiated with improved data. One aspect of the overestimate is the fact that downsizing to an I4 from a V6 shows virtually no difference in cost, despite real world evidence that such a change is accompanied by much-reduced costs, or even net savings. We recommend the agencies revert back to EPA's previous analysis in the TAR and original Final Determination on these downsized turbocharged engine costs.

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[257] *Draft TAR section 5.3.2.1 at 5-229*

[258] *Aaron Isenstadt and John German (ICCT); Mihai Dorobantu (Eaton); David Boggs (Ricardo); Tom Watson (JCI). Downsized boosted gasoline engines, October 28, 2016. http://www.theicct.org/downsized-boosted-gasoline-engines*

[259] *Id. and Draft TAR Tables 5.68 through 5.72*

[260] *EPA compares its 24-bar BMEP engine to current modern turbo-downsized engines in the Proposed Determination TSD Figures 2.113 through 2.115. EPA's response to comments begin on 2-318 of the Proposed Determination TSD; and section 2.5.2 of the Final Determination Response to Comments.*

Table 10. Technology cost on turbocharging and downsizing

	Cost		
	I4 to I3	V6 to I4	V8 to V6
Agency 18bar turbo (over VVT)	$638	$642	$1,052
Agency 24bar turbo (over 18bar)	$204	$204	$343
Agency CEGR (over 24bar)	$244	$244	$244
Updated, appropriate (ICCT, EPA) 18bar (over VVT)	$315	($391)	$376
Updated, appropriate (ICCT, EPA) 24bar (over 18 bar)	$223	$223	$387
Updated, appropriate (ICCT, EPA) CEGR (over 24 bar)	$116	$116	$149

That turbocharging costs in the NPRM have been inappropriately inflated is supported by a real-world example. The 2018 Ford Fusion is offered with 3 engine options, a 2.5L naturally aspirated, a 1.5L turbo, and a 2.0L turbo. The 2.5L is standard on the Fusion SE and the 1.5L turbo is a $400 option.[261] As the agencies apply a Retail Price Equivalent of 1.5 to establish retail prices,[262] this means that the technology cost of the Fusion 1.5L turbo is less than $270 – less than half the estimate in the NPRM and even less than the ICCT and EPA's updated estimate shown above.

The errors in the agencies' cost analysis of turbocharging goes beyond the above comparisons. In particular, as discussed above, the step from turbocharging to cooled EGR offers no CO_2 or fuel consumption effectiveness benefit in the model, contrary to the real-world. Also as discussed above, the agencies own benchmarking and simulation modeling clearly show that there is a benefit to CEGR on top of turbocharging of 3-4%, demonstrating that the agencies' modeling contains obvious error. Although the real-world cost-effectiveness of this technology demonstrates that it is appropriate to include it within an improved and appropriate progression of technologies on turbocharged engines, the CEGR efficiency values (and the algorithms' general failure to choose only cost-effective technologies) must be fixed. Other turbocharging technologies are also available that can further reduce fuel consumption, yet were not considered at all in the NPRM. The Miller cycle can provide an additional 4%-5% benefit at a cost of $0 - $67; axial flow turbines and variable geometry turbos offer 1-2% benefit for $67; and e-boosting alone can provide another 2%-5% benefit (greater if coupled with a 48-volt mild hybrid system) for $400.[263]

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261 *Ford Fusion engine options shown in https://www.msn.com/en-us/autos/ford/fusion/2018/options/se-fwd/sd-BBCjYN9 and https://shop.ford.com/build/fusion/2018/, both accessed in October 2018.*

262 *PRIA section 9.2.5 at 1202*

263 *Aaron Isenstadt and John German (ICCT); Mihai Dorobantu (Eaton); David Boggs (Ricardo); Tom Watson (JCI). Downsized boosted gasoline engines, October 28, 2016. http://www.theicct.org/downsized-boosted-gasoline-engines*

Mild hybrid 48-volt hybrid systems. 48-volt mild hybrids are another example of a technology where the agencies' cost is inflated. This is supported by both the ICCT/supplier technology report on hybrids[264] and by a real world example, the 2019 RAM 1500 pickup truck.

There appears to be discrepancies in the agencies' reporting of battery costs in the PRIA compared to the input files of their compliance model. In a departure from the draft TAR, the agencies separate battery and non-battery costs and bury the battery costs used in the CAFE model inside a database.[265] [266] [267] Not only is this database exceedingly difficult to access to modify battery costs (as battery costs should be a user input), but it makes it much harder to see how battery costs affect mild hybrid costs over time. On top of this, the agencies appeared to have used outdated and grossly overstated battery costs in their analysis. This conclusion is based on the tables in section 6.3.9.12 of the PRIA, as well as the outputs of the agencies' low battery cost sensitivity run of the Volpe model. In that run, which used battery costs more closely in line with EPA's and leading research on battery costs (see more on this below), the per-vehicle cost of compliance with 2025 standards decreased by $214.[268] We were unable to make these written and datafile costs match up and NHTSA and Volpe staff did not respond to our request for clarification. Our best estimate of BISG costs from the NPRM are listed in Table 11, but these may not be completely accurate, due to the agencies incomplete efforts to disclose all their assumptions to the public in an discernible and accessible way.

Contrasting with the agencies' analysis is the 2019 RAM 1500 pickup truck, which, when it was first introduced early in the summer of 2018, offered a BISG hybrid system as a free standing option for $800[269]. The price increment was recent raised to $1,450[270].The 48-volt system is branded as an "eTorque" system that provides 130 pound-feet of electric torque for greater utility and acceleration.[271] Even with the new, higher price, applying the agencies RPE of 1.5, this means the direct manufacturing cost is less than $1,000, much less than the $1,616 direct manufacturing cost estimate in the NPRM for 2016 pickup trucks.[272]

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[264] *John German. Hybrid vehicles: Trends in technology development and cost reduction, July 23, 2015, https://www.theicct.org/publications/hybrid-vehicles-trends-technology-development-and-cost-reduction*

[265] *PRIA section 6.3.9.12 at 375*

[266] *2018 CAFE Model Documentation, section 4.7.2 at 46.*

[267] *"Battery_Costs.csv" input datafile of the agencies at National Highway Safety Traffic Administration, 2018, "Compliance and Effects Modeling System." https://www.nhtsa.gov/corporate-average-fuel-economy/compliance-and-effects-modeling-system.*

[268] *Low battery cost sensitivity analysis "Compliance report" output datafile and standard-setting "compliance report" output datafile from National Highway Safety Traffic Administration, 2018, "Compliance and Effects Modeling System." https://www.nhtsa.gov/corporate-average-fuel-economy/compliance-and-effects-modeling-system*

[269] *Aaron Cole. The Car Connection. https://www.thecarconnection.com/news/1115635_2019-ram-1500-truck-will-cost-33340-to-start-around-60k-fully-equipped*

[270] Mark Phelan. USA Today. *https://www.freep.com/story/money/cars/mark-phelan/2018/08/24/2019-ram-mild-hybrid-first-drive-mark-phelan/1069729002/*

[271] Id.

[272] *PRIA at 1113, Table 9-3*

Note that the eTorque system offers improved performance and drivability and contributes to higher payload and towing ratings for 2019 compared with 2018.[273] In fact, the very branding of the option as eTorque suggests that RAM believes the utility benefits are of value to customers – yet the agencies have completely failed to account for the consumer value of the utility benefits. Therefore, this is not an equal-performance comparison.

The agencies modeled costs for BISG systems for cars and small SUVs appear to be even more off base. In particular, the cost of BISG systems are modeled as being approximately $600 more expensive for cars and small SUVs than those for pickups and medium SUVs.[274] This appears to run counter to the agencies' own brief descriptions of battery and electrification costs in the PRIA.[275] It is also contrary to basic engineering logic, which holds that a system which would be smaller and have lower energy and power requirements would be less expensive, not more.

Based on the joint 2016 ICCT/supplier analysis of 48-volt mild-hybrid systems[276] 48V hybrid system cost is $600-$1,000 (with costs lower on the lower side for cars and higher side for light trucks) in the 2025 timeframe. As discussed above, the RAM 1500 pickup has already validated the ICT figures in 2019. In contrast, the agencies' figures are contrary to this best-available research and real-world evidence. Using these updated estimates would reflect industry practices for developing these systems, ensure constant-utility, and match the technology improvement of 10-15% for the given technology benefits. The agencies must use more reasonable cost estimates in their rulemaking.

Table 11. Technology cost on 48-volt mild hybrids

	Cost	CO_2 and fuel consumption reduction effectiveness
Agency BISG (over IACC)	$1,365 – $1,616	5.7% - 6.7%
ICCT technology report – mild hybrids	$600 – $1,000	10% - 15%

Full hybrids. The agencies have substantially overestimated the costs of full hybrid vehicles. Because we continue to be unable to decipher the agencies' multiple and inconsistent hybrid cost components, we analyzed the complete vehicle costs (rather than the bottom-up cost components) for strong hybrids. But we emphasize that, due to the confusing and inconsistent costs in this technology, among others, the agencies must release a clear explanation of these cost components, and provide an additional opportunity for public comment.

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[273] *2018 RAM Pickup specifications: https://www.edmunds.com/ram/1500/2018/features-specs/*
2019 RAM Pickup specifications: https://www.edmunds.com/ram/1500/2019/features-specs/

[274] *Compare PRIA Table 6-32 (cars & small SUVs) with PRIA Table 6-33 (trucks and medium SUVs)*

[275] *PRIA Tables 6-29 and 6-30*

[276] *Aaron Isenstadt and John German (ICCT); Mihai Dorobantu (Eaton); David Boggs (Ricardo); Tom Watson (JCI). Downsized boosted gasoline engines, October 28, 2016. http://www.theicct.org/downsized-boosted-gasoline-engines*

We analyzed the agencies' final output files in the Augural standard analysis, which indicate their full hybrid vehicle costs – for all the vehicles that had hybrid technology applied during the compliance period (i.e., removing those models that were already hybrid in 2016). This revealed the modeled incremental price increase for hybrids was approximately $6,600 per hybrid vehicle in 2017, decreasing to $4,800 in 2025.

As analyzed in our previous work,[277] this is not a plausible result, considering hybrid component costs and full-vehicle prices in the marketplace in 2016 as well as the technology improvement that continues to enter the fleet. Full hybrid systems are options on dozens of mass market vehicles. The agencies have continued to fail to properly analyze those dozens of hybrids in the marketplace, their much lower costs than the agencies are assuming, and their rapid improvements due to high-activity among automakers and suppliers to competitively develop lower cost components.

The agencies must set a maximum cost premium for full hybrids (which improve CO_2 and fuel consumption by 30%-35%) of $2,500 in 2017, declining linearly to $1,400 by 2025 for mid-size cars and crossovers.[278] The cost components would also likely scale by vehicle power requirements, up for pickups, down for smaller cars, which the agencies must also account for in the modelling.

The agencies must completely and transparently disclose the basis for their cost estimates, to enable the public to clearly connect the bottom-up cost components (e.g., battery and power electronic costs) to full vehicle costs for all vehicle models that have hybrid costs applied in the existing and Augural 2025 standards. To date, the documentation (or lack thereof) provided by the agencies veils from public view their justifications for unrealistically high hybrid cost estimates—one of the most important technology cost estimations to assess the Augural standards' compliance cost, as the NPRM projects that 22% of vehicles will need full hybrid systems to meet the augural standards. The various components of these costs be made explicit and justified with real-world analysis and evidence. After disclosing these costs, the agencies must provide another opportunity for public comment.

Mass reduction. The agencies have unjustifiably impeded the uptake of mass reduction technology, and have unrealistically inflated the associated costs. As discussed above, it appears that the agencies have invalidly assumed that 47% of baseline vehicles already have some level of this technology , thereby artificially removing the most cost-effective lightweighting from future use. This means that for nearly half of vehicles to adopt any lightweighting at all, they must skip past the least expensive options, and adopt only more advanced, more

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[277] *John German (ICCT). Hybrid vehicles: Trends in technology development and cost reduction, July 23, 2015. http://www.theicct.org/hybrid-vehicles-trends-technology-development-and-cost-reduction. This work has been shared with the agencies on multiple occasions before the 2018 NPRM*

[278] *John German (ICCT). Hybrid vehicles: Trends in technology development and cost reduction, July 23, 2015. http://www.theicct.org/hybrid-vehicles-trends-technology-development-and-cost-reduction. This work has been shared with the agencies on multiple occasions before the 2018 NPRM*

expensive options. This incorrectly increases the costs of all subsequent mass-reduction in the compliance modeling.

Moreover, the agencies have unrealistically inflated the costs associated with the various levels of mass reduction. There are numerous material improvements in development that were not considered in the rule,[279] such as higher strength aluminum,[280] improved joining techniques for mixed materials, third-generation steels with higher strength and enhanced ductility,[281] a new generation of ultra-high strength steel cast components, and metal/plastic hybrid components.[282] And these developments are just a sample of the developments discussed in the joint ICCT/supplier technology working paper on lightweighting that are ignored in the proposal. [283]

The National Academies[284] specifically endorsed tear-down studies as the most appropriate way to get at vehicle technology costs. These studies are typically more accurate and far more transparent than the older method of surveying manufacturers, and such whole-vehicle studies are key to capturing holistic vehicle level mass-reduction technology costs. There are many such studies that have assessed mass reduction technology and costs since 2011. Peer-reviewed studies, including by EDAG, FEV, Ford, and Lotus Engineering use state-of-the-art engineering teardown analysis and holistic vehicle safety simulation analysis to assess mass-reduction technology and its cost; these studies demonstrate that at least 20% mass reduction is available for adoption across vehicle classes by 2025.[285] Yet the agencies have either

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[279] *In PRIA section 6.3.10.1.1, no mention is made of higher strength aluminum, third generation advanced high strength steel, nor improved joining (for example glue or other adhesives). The lightweighting study used as the basis for mass reduction costs (PRIA Table 6-37), shows only material substitution using none of the above-listed materials.*

[280] *Richard Truett. "Novelis: Automakers test stronger aluminum." Auto News. August 10, 2015. Web. Accessed July 2016. http://www.autonews.com/article/20150810/OEM01/308109982/novelis:-automakers-test-stronger-aluminum*

[281] *Ryan Gehm. "NanoSteel confident its new AHSS is ready for volume production." Automotive Engineering. July 17, 2016. Web. Accessed July 2016. http://articles.sae.org/14908/*

[282] *Mana D. et.al "Body-in-white Reinforcements for Light-weight Automobiles", SAE technical paper # 2016-01-0399. Nagwanshi D. et.al, "Vehicle Lightweighting and Improved Crashworthiness – Plastic/Metal Hybrid Solutions for BIW", SPE ANTEC, technical program, 2016.*

[283] *Aaron Isenstadt and John German (ICCT); Piyush Bubna and Marc Wiseman (Ricardo Strategic Consulting);); Umamaheswaran Venkatakrishnan and Lenar Abbasov (SABIC); Pedro Guillen and Nick Moroz (Detroit Materials); Doug Richman (Aluminum Association), Greg Kolwich (FEV). Lightweighting technology development and trends in U.S. passenger vehicles, December 19, 2016. http://www.theicct.org/lightweighting-technology-development-and-trends-us-passenger-vehicles*

[284] *National Academies. Cost, Effectiveness, and Deployment of Fuel Economy Technologies for Light-Duty Vehicles. 2015. https://www.nap.edu/catalog/21744/cost-effectiveness-and-deployment-of-fuel-economy-technologies-for-light-duty-vehicles*

[285] *EDAG (2011) Future Steel Vehicle. http://www.worldautosteel.org/projects/future-steel-vehicle/phase-2-results/ Prepared for WorldAutoSteel. FEV (2012) Light-Duty Vehicle Mass Reduction and Cost Analysis — Midsize Crossover Utility Vehicle. Prepared for US Environmental Protection Agency. EPA-420-R-12-026. http://www.epa.gov/otaq/climate/documents/420r12026.pdf; Lotus Engineering (2012) Evaluating the Structure and Crashworthiness of a 2020 Model-Year, Mass-Reduced Crossover Vehicle Using FEA Modeling. Prepared for California Air Resources Board. http://www.arb.ca.gov/msprog/levprog/leviii/final_arb_phase2_report-compressed.pdf; Singh, H. (2012). Mass Reduction for Light-Duty Vehicles for Model Years 2017-2025. Prepared for National Highway Traffic Safety Administration. Report No. DOT HS 811 666. ftp://ftp.nhtsa.dot.gov/CAFE/2017-25_Final/811666.pdf (accessed in 2012); Geck, P. J. Goff, R. Sohmshetty, K. Laurin, G. Prater, V. Furman, 2007. IMPACT Phase II – Study to Remove 25% of the Weight from a Pick-up*

incorrectly interpreted or invalidly nullified the most relevant detailed engineering teardown studies on mass-reduction technology.

In the Draft TAR, the agencies based their direct manufacturing costs on a study that reduced the mass of a MY2011 Honda Accord by first shedding glider weight, then downsized powertrain components to maintain equivalent performance. The cumulative cost per kilogram before powertrain downsizing was $2.69 (for a net reduction of 10.74% of the curb weight, or 13.6% of the glider weight).[286] After downsizing the powertrain—which led to cost savings—the net cost per kilogram was estimated to be $1.20 (20.52% reduction in curb weight).[287] This same study was used in the NPRM. However, in the NPRM, only glider weight reduction is ever considered, without the cost-offsetting engine downsizing. Thus, not only do the agencies omit a key cost component that reduces total costs, they also erroneously improve vehicle performance, contrary to their own assertion and intention to assume a constant performance trend. Additionally, the omissions mean the agencies fail to account for associated the powertrain weight reductions (which allow higher total mass reduction - up to 20% total mass reduction - and thus even greater efficiency benefits at a lower cost per kilogram than glider weight reduction alone), and instead create a new mass reduction cost curve that peaks at 20% reduction in *glider* mass at nearly $16 per kilogram. The agencies do not offer explanation to justify this sudden and dramatic increase.[288] The agencies acknowledge the potential to enable powertrain downsizing and realize its associated fuel efficiency benefits by reducing glider mass by more than 10%. However, it is unclear if, and how, costs are reduced while downsizing, as well as the precise changes to fuel efficiency.

We recommend the agencies adjust their technology cost inputs to reflect best-available technology studies.[289] The correct cost assumption from all these studies is that a 5-10% mass

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Truck. Society of Automotive Engineers. 2007-01-1727 https://www.sae.org/publications/technical-papers/content/2007-01-1727/. Caffrey et al, 2015. Cost-Effectiveness of a Lightweight Design for 2020-2025: An Assessment of a Light-Duty Pickup Truck https://www.epa.gov/sites/production/files/2016-10/documents/2015-01-0559_0.pdf. Caffrey et al, 2013. Cost-Effectiveness of a Lightweight Design for 2017-2020: An Assessment of a Midsize Crossover Utility Vehicle. https://www.sae.org/publications/technical-papers/content/2013-01-0656/

286 *PRIA at 393 and Table 6-37*

287 *Draft TAR Table 5.175, p 5-422*

288 *PRIA Figure 6-160*

289 *EDAG (2011) Future Steel Vehicle. http://www.worldautosteel.org/projects/future-steel-vehicle/phase-2-results/ Prepared for WorldAutoSteel. FEV (2012) Light-Duty Vehicle Mass Reduction and Cost Analysis — Midsize Crossover Utility Vehicle. Prepared for US Environmental Protection Agency. EPA-420-R-12-026. http://www.epa.gov/otaq/climate/documents/420r12026.pdf; Lotus Engineering (2012) Evaluating the Structure and Crashworthiness of a 2020 Model-Year, Mass-Reduced Crossover Vehicle Using FEA Modeling. Prepared for California Air Resources Board. http://www.arb.ca.gov/msprog/levprog/levili/final_arb_phase2_report-compressed.pdf; Singh, H. (2012). Mass Reduction for Light-Duty Vehicles for Model Years 2017-2025. Prepared for National Highway Traffic Safety Administration. Report No. DOT HS 811 666. ftp://ftp.nhtsa.dot.gov/CAFE/2017-25_Final/811666.pdf (accessed in 2012); Geck, P. J. Goff, R. Sohmshetty, K. Laurin, G. Prater, V. Furman, 2007. IMPACT Phase II – Study to Remove 25% of the Weight from a Pick-up Truck. Society of Automotive Engineers. 2007-01-1727 https://www.sae.org/publications/technical-papers/content/2007-01-1727/. Caffrey et al, 2015. Cost-Effectiveness of a Lightweight Design for 2020-2025: An Assessment of a Light-Duty Pickup Truck https://www.epa.gov/sites/production/files/2016-10/documents/2015-01-0559_0.pdf. Caffrey et al, 2013. Cost-Effectiveness of a Lightweight Design for 2017-2020: An Assessment of a Midsize Crossover Utility Vehicle. https://www.sae.org/publications/technical-papers/content/2013-01-0656/*

reduction by 2025 reduces vehicle cost, and the auto industry will cost-effectively deploy at least 15% vehicle curb mass reduction in the 2025 timeframe at near zero net cost (and consistently less than $500). The agencies should thus increase the maximum available mass reduction potential levels to include 20%-25% mass reduction to reflect the potential and associated costs as shown in the leading teardown studies.[290] This would reflect actual industry practices to incorporate all the available and emerging mass-reduction technologies.

Electric vehicle battery costs. Electric vehicles are by and large unnecessary for companies to comply with the 2025 augural fuel economy and existing GHG standards, as demonstrated by the agencies' analyses in the Draft TAR and the EPA 2016-2017 Proposed and original Final Determination.[291] This remains true in the NPRM,[292] even with all of the artificial restrictions placed on conventional powertrain technologies as discussed in Section II. Nonetheless, we find that the agencies' inputs have failed to reflect the leading industry data on how rapidly these technologies are approaching cost parity with combustion vehicles. Overall the agencies appear to have overestimated electric vehicle costs dramatically. The agencies have purported to utilize state-of-the-art tools including the DOE BatPac model on battery costs, but their cost calculations have erroneously pushed up electric vehicles' incremental costs above $10,000 per vehicle. The agencies have thus introduced errors that have artificially pushed up the battery costs much higher than indicated by BatPac and other experts in the field.

Table 12 summarizes the most reliable available projections of electric vehicle battery costs for 2020-2030.[293] The agencies have not analyzed these studies to understand the potential for cost-effective electric drive technology. The data include a variety of different technologies, production volumes, and cost elements. Although there are differences in the methods, they

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[290] *Ibid.*

[291] *Draft TAR Tables 12.29 through 12.42; Proposed Determination Table IV.5 (not the technical support document)*

[292] *PRIA Tables 7-49, 7-53, 7-57*

[293] *Ahmed, S., Nelson, P., Susarla, N., Dees, D. (2018). Automotive Battery Cost Using BatPac. IEA Workshop on Batteries for Electric Mobility. https://www.iea.org/media/Workshops/2018/Session2ShabbirAhmedANL.pdf*

Anderman, M. (2016). The Tesla battery report: Tesla Motors: Battery technology, analysis of the Gigafactory and Model 3, and the automakers' perspectives. Retrieved from http://www.totalbatteryconsulting.com/industry-reports/Tesla-report/Extract-from-the-Tesla-Battery-Report.pdf

Anderman, M., (2018, June). The xEV Industry Insider Report. Retrieved from https://totalbatteryconsulting.com/industry-reports/xEV-report/Extract-from-the-2018-xEV-Industry-Report.pdf

Anderman, M., (2018). Progress in EV-Battery Cell Cost and Performance: How Far and How Fast?. SAE Hybrid Vehicle Symposium. Retrieved from http://www.pvsheridan.com/SAE-2018/2.30%20pm%20-%20Menahem%20Anderman,%20Total%20Battery%20Consulting.pdf

Berckmans, G., Messagie, M.,, Smekens, J., Omar, N., Vanhaverbeke, L. & Van Mierlo, J. (2017) Cost Projection of State of the Art Lithium-Ion Batteries for Electric Vehicles Up to 2030. Energies 2017, 10(9), 1314. Retrieved from http://www.mdpi.com/1996-1073/10/9/1314

Davies, C., (2017). VW I.D. EV boast: We'll hugely undercut Tesla's Model 3 says exec. Retrieved from https://www.slashgear.com/vw-i-d-ev-boast-well-hugely-undercut-teslas-model-3-says-exec-17491688/

Holland M., (2018). Tesla aiming to break $100/kwh at cell-level later this year. https://evobsession.com/tesla-aiming-to-break-100-kwh-at-cell-level-later-this-year/

Lienert, P, & White, J. (2017). GM races to build a formula for profitable electric cars. Retrieved from https://www.reuters.com/article/us-gm-electric-insight/gm-races-to-build-a-formula-for-profitable-electric-cars-idUSKBN1EY0GG

UBS. (2017). UBS evidence lab electric car teardown: Disruption ahead? Retrieved from https://neo.ubs.com/shared/d1ZTxnvF2k/

generally include in some variation of material, process, overhead, depreciation, warranty, and profit costs; an exception is that the Ahmed et al (2018) study excludes profit. In addition, the table shows statements regarding battery costs from automakers. These are in the three bottom rows. As shown, most of the studies and automaker statements show battery pack costs declining to $150/kWh by 2020-2023 and then to about $120-135/kWh by 2025. The exception is Tesla, which (as shown in the bottom row) reports an accelerated cost-decline, stating that it reached $150/kWh in 2018 and will reach $100/kWh by 2022, associated with its earlier high-production than others.

Table 12. Battery electric vehicle pack cost ($/kWh)

Source	2020	2022	2025	2030	Notes
Ahmed et al, 2018	143	134	122		Pouch NMC 6,2,2-graphite, production volume-based; includes total cost to automaker for material, process, overhead, depreciation, warranty
Anderman, 2018a		142			Cylindrical 21700, NCA 83,13,4, production volume-based; includes cost of material, capital, pack integration, labor, overhead, depreciation, R&D, general administration, warranty, profit
Anderman, 2018b	160		130		Pouch NMC 8,1,1-graphite, production volume-based; includes cost of materials, capital, pack integration, labor, overhead, depreciation, R&D, general administration, warranty, profit
Berckmans et al, 2017	191	165	120	80	Pouch NMC 6,2,2-graphite, production volume-based; includes material, process, labor, overhead, depreciation, profit
UBS, 2017	184		133		Pouch NMC 6,2,2-graphite, production volume-based; includes material, process, labor, overhead, depreciation, profit
Davies, 2017	152				Volkswagen statement. Associated with planned production volume of 100,000 per year by 2020 for I.D. series
Lienert & White, 2017	160	133			General Motors statement. Associated with Chevrolet Bolt, production volume has not been stated
Holland, 2018	130	100			Tesla statement. Stated Model 3 production volume of 500,000 with associated Panasonic battery production in Nevada by 2020

NMC = Nickel Manganese Cobalt Oxide; NCA = Nickel Cobalt Aluminum; Unless cell and pack costs provided within study, cell-to-pack cost ratio of 0.75 assumed; Unless stated otherwise within study, matching production volumes to year assumes 100,000 units/year in 2020 and 500,000 units/year for 2025; See studies for additional details, sensitivity analysis, differing chemistries, etc

Our findings are corroborated by EPA's analysis of the chosen Autonomie/CAFE battery costs used in the proposal, as shared in interagency emails and posted in the rulemaking docket. The battery costs appear to be 20% to 40% higher that the estimates that EPA has found in the same BatPaC model used by ANL.[294] Based on the interagency dialogue between EPA and NHTSA, it is clear that EPA's experts not only found battery costs to be too high compared to their own analysis of the BatPac model that was used, but NHTSA did not even provide enough information to allow EPA to understand why the newly-assumed battery costs were so inexplicably high:

[294] *"Email 5": Email_5_-_Email_from_William_Charmley_to_Chandana_Achanta_-_June_18,_2018. https://www.regulations.gov/document?D=EPA-HQ-OAR-2018-0283-0453. Page 66. "The cost of batteries for hybrid and plug-in vehicles is in most cases significantly higher than expected based on the most recent projections derived from DOE's BatPaC model." The info indicates that the final chosen in NHTSA/ANL battery costs for MY2029 were as follows: BISG batteries 40% higher than BatPaC MY2021; SHEVP2 20% higher; BEV200 40% higher; PHEV50 23% higher than EPA PHEV40*

> "Overall, battery costs included in this analysis are higher than what EPA has obtained from the most recent version of the BatPaC model. There is not enough detail provided for EPA to determine what is contributing to these higher costs, but two potential factors are notable. First, the text refers to both ANL/ESD-15/28 and the BatPac model, so there are potentially inconsistencies in the application of assumptions from one of these sources to the other. Second, the text frequently refers to the BatPaC model to lend authority to the battery cost estimates, without providing sufficient information on the much more significant issue of how battery sizing or other model inputs were determined, much less the battery sizings or cost estimates that resulted"[295]

The agencies have not resolved, reconciled, or even discussed these clear problems in NHTSA's erroneous use of the BatPac numbers their rulemaking documentation. The agencies have largely obscured their battery electric vehicle (BEV) cost sources or calculations, making it nearly impossible for even very interested researchers to understand how all the BatPac costs translate into BEV costs that can be compared with other full-BEV costs in the literature. To enable meaningful public comments, these sources and cost calculations must be made explicit and the agencies must provide an additional public comment opportunity.

Furthermore, from the datafiles available, it appears clear that the agencies have not assessed the ability for BEV efficiency improvements from load reduction (weight, rolling resistance, aerodynamic) to reduce the battery and power electronic component sizing, thereby reducing battery costs. If BEVs battery and other component costs are considered appropriately, cost parity with conventional combustion vehicles will be reached in the 2025-2027 timeframe.[296]

In addition, the agencies prevented their fleet compliance model from allowing battery electric vehicles from being applied in their analysis of the Augural standards. If the agencies include appropriate BEV costs (where BEVs achieve cost parity in the 2025-2027 timeframe), and remove all their constraints on electric vehicles, they would appropriately realize that the 2025 standards are more cost-effective when electric vehicles are included.

Tier 3 vs Tier 2 fuel. In the NPRM modeling the agencies incorrectly apply fuel economy and CO_2 penalties to the switch from Tier 2 to Tier 3. In its Proposed Determination, EPA explicitly states that it did not base any technology effectiveness values on engines requiring high octane fuel.[297] On the contrary, EPA selected technologies assuming regular 87 AKI fuel and included technologies "necessary to protect for operation on such fuels." Thus, if the agencies had appropriately used the most up-to-date and recently vetted vehicle simulation tool available to

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[295] *"EO_12866_Review_EPA_comments_on_NPRM_and_Preliminary_RIA_sent_to_OMB,_July_26,_2018". https://www.regulations.gov/document?D=EPA-HQ-OAR-2018-0283-0453. Page 1142.*

[296] *Paul Wolfram and Nic Lutsey. Electric Vehicles: Literature review of technology costs and carbon emissions. International Council on Clean Transportation. http://www.theicct.org/lit-review-ev-tech-costs-co2-emissions-2016 and Pete Slowik and Nic Lutsey. Evolution of incentives to sustain the transition to a global electric vehicle fleet. https://www.theicct.org/publications/evolution-incentives-sustain-transition-global-electric-vehicle-fleet*

[297] *EPA Proposed Determination TSD at 2-211. In addition, EPA showed that use of Tier 3 fuel often resulted in reduced CO2 emissions compared to use of Tier 2 fuel. Id.*

them (i.e., ALPHA modeling), they would not have needed to inappropriately modify the engine maps for advanced engine technologies. We also discuss this fuel topic above, as it applies to the agencies choices of, and their adjustments to, engine maps.

Learning curves. A subtle change by the agencies in this NPRM is in the learning curves of all technologies. In the NPRM, the agencies use a decaying exponential function. In the TAR, the agencies used fixed rates of cost decline over set time increments.[298] EPA's learning curve rates used in the TAR and in its Final Determination used a decaying curve, but less steep than the NPRM. In the NPRM, the agencies used safety technology as a proxy for fuel efficiency technology in order to determine learning effects.[299] As a result, the learning curves for many important fuel efficiency technologies are not as steep as in the TAR. That is, the decrease in cost over time is lower in the NPRM than it is in the TAR. Safety technology was chosen for the NPRM because it is used by almost every manufacturer. The nature of fuel efficiency technologies (particularly advanced ones) is that not every manufacturer will use them, especially not when they are first introduced. Consequently, the choice of safety technology as a model for fuel efficiency technology leads to lower rates of learning. This is further emphasized by the fact that EPA in both the TAR and its Final Determination also used decaying exponential learning curves based on empirical data. These curves were, broadly speaking, less steep than NHTSA's in the TAR, but were also steeper than the agencies' curves in the NPRM.

Examples comparing the TAR and NPRM differences due to learning rate discrepancies include (over the years 2016-2025):

- Turbodownsizing (all levels) show 18%-24% slower learning rate
- 67% reduction in learning for VVT, VVL, SGDI, DEAC
- 21% reduction in learning for HCR (as compared to EPA's Atkinson cycle engine)
- 29% reduction in learning for batteries (as compared to EPA's battery learning curves)

To show the impact of changing learning rates, the agencies should run a sensitivity analysis similar to the ICM sensitivity run (using EPA's indirect cost multipliers). In the learning rate sensitivity, the agencies should consider the learning rates used in the TAR, as well as EPA's learning rates in its Final Determination. Without doing so and without conducting a peer review of the change in approach, it appears clear the agencies have decided to switch to a new costing method that affects all future costs, but without any significant research justification, vetting, or review.

Indirect costs and retail price equivalent. The agencies abandoned their previously-used indirect cost multiplier method for estimating total costs, which was vetted with peer review, and more complexly handled differing technologies with different supply chain and manufacturing aspects. The agencies have, at this point, opted to use a simplistic retail price equivalent method, which crudely assumes all technologies have a 50% markup from the direct

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[298] *Draft TAR at 5-435*
[299] *PRIA section 9.3.2, p 1209*

manufacturing technology cost. We recommend the agencies revert back to the previously-used and better substantiated ICM approach.

2. *Technology package cost effectiveness*

In the construction of packages for the technology sequencing, the agencies have made systematic errors that do not reflect automaker decisions on adoption of technologies. We point out several specific examples that we believe are representative of a deeply flawed logic with nearly no quality control steps to vet for realistic sequencing of technology adoption reflecting best available data on technology costs and effectiveness.

The effect of artificial exclusion of improved technologies and restrictions on market penetration discussed in this section are exacerbated by their impact on the technology cost-benefit curve. Manufacturers usually add technology from the most cost-effective (i.e. the largest efficiency benefit per dollar) to the least cost-effective. If low cost technologies are ignored or constrained in the model, more costly technologies must be used instead. This is illustrated in Figure 3, which shows the incremental benefits and costs for technologies assessed by EPA in their Final Determination.[300] As the figure demonstrates, the slope of the curve rises smoothly from one technology to the next, as each proves slightly less efficiency gain-per-dollar than the last. As discussed further below (and shown in Figure 4), the technology pathway curves for the NPRM do not rise smoothly, instead jogging between more and less cost-effective technologies as they progress. This causes compliance to be more expensive, in part because limitation on cost-effective technology early in the path forces the model to adopt the more expensive technologies later in the path. For example, The NPRM analysis projects that 32% of all vehicles needed 48V mild hybrids and an additional 22% needed full hybrids to comply with the augural standards.[301] As can be seen in the figure, 48V hybrids are far above the "elbow" separating cost-effective to cost-ineffective technologies in the agencies' and Draft TAR analysis – they were the least cost-effective option assessed by EPA. And full hybrids, were not even included in EPA's Draft TAR modeling because they were not needed, are far higher cost and less cost-effective even than 48V hybrids. Thus, it appears that limitations on cost-effective conventional technologies below the elbow in the NPRM modelling have forced the model to adopt technologies at the top end of the curve to compensate, dramatically increasing the total cost of compliance for every restriction.

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[300] *Nic Lutsey, Dan Meszler, Aaron Isenstadt, John German, Josh Miller. Efficiency technology and cost assessment for U.S. 2025–2030 light-duty vehicles. March 22, 2017* https://www.theicct.org/publications/US-2030-technology-cost-assessment

[301] *"Compliance Report"* outputs from NHTSA datafiles. National Highway Safety Traffic Administration, 2018, "Compliance and Effects Modeling System." https://www.nhtsa.gov/corporate-average-fuel-economy/compliance-and-effects-modeling-system

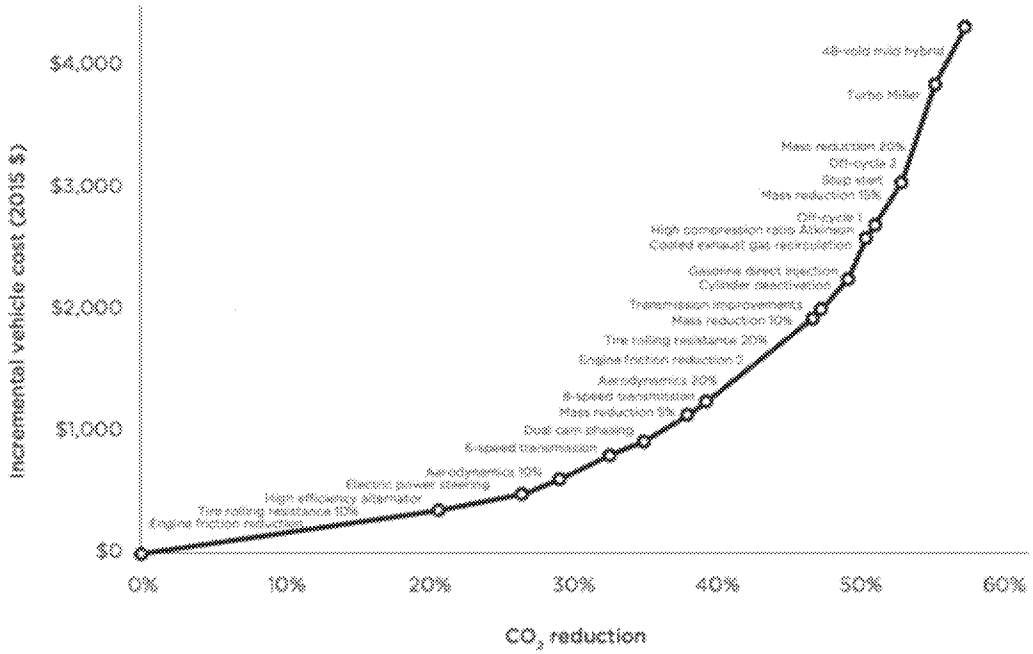

Figure 3. Lowest cost efficiency technology progression for CO2 reduction in passenger cars and crossover vehicles.

The following is a series of findings regarding these technology constraints based on our analysis of many sensitivity cases using the same CAFE model used by the agencies, to explore how the agencies' CAFE model is working based on its inputs and algorithms. We found that examining the outputs corroborates the conclusion that many of the inputs and methodological choices of the agencies are erroneous, as discussed above.

- *Cooled exhaust gas recirculation*. CEGR1 added to TURBO2 has 0.0% effectiveness with $359 total per-vehicle cost in 2025. These assigned characteristics would make this an unattractive technology for manufacturers, with added cost and no benefit. We investigated further to see how the agencies' fleet compliance modeling utilized the technology. When we blocked the adoption of CEGR1, it reduces 2025 Augural standards cost of compliance by $116. Of course removing a technology should not decrease the cost of meeting the standard, as that should mean removing the technology results in the adoption of a different and less cost effective set of technology. The model is supposed to be designed to choose the more cost effective technologies first and the less cost effective later, not the other way around. This reveals a CAFE modeling approach that is poorly designed and subject to poor quality control, and fails in its sole purpose of projecting on auto companies' cost-effective technology approaches using the agencies' technology and cost inputs.
- *High compression ratio.* As a sensitivity analysis, the agencies chose to run the CAFE model in which they activated HCR2. This one change alone reduced the total per-vehicle cost of compliance with the Augural 2025 standards by $690. Because the

agencies restricted the use of HCR2 in their primary analysis, this shows that the agencies intentionally excluded a highly cost-effective technology (by their own analysis) in the rulemaking analysis. As discussed above, they apparently did so based on an invalid technical assumption. In the ICCT modeling, we found that by activating HCR2 as well as making all technology applicable to all automakers' engines, transmissions, and platforms, compliance costs with the 2025 Augural standards were reduced by $817.

- *Electric vehicles*. The agencies also ran their model with reduced battery costs, which is directionally appropriate as their estimated battery and overall electric vehicles are well out of line with leading research, as indicated above. This scenario appears to reduce the cost of compliance by $220. Through a combination of incorrectly high electric vehicle prices (that do not reflect ANL[302] or other leading battery research groups' work)[303], and modeling restrictions on electric vehicles, the agencies have unduly inflated technology costs of electric vehicles to comply with the standards.

Figure 4 illustrates the cumulative effect of the agencies' unsubstantiated technology cost and effectiveness inputs, as well as inappropriate constraints on technologies and manufacturers, using the agencies modeling.[304] For a Medium Car (MedCar) vehicle class, following the turbocharging (Turbo) path in blue results in a 37% reduction in fuel consumption at a cost of over $5,000. On the other hand, using the agencies' own technology inputs and following the HCR path (brown) leads to similar levels of fuel savings at a cost of around $3,450. As explained above, the HCR path is only available for a select group of engines from a select group of manufacturers, due to artificial and inappropriate decisions made by the agencies' modeling.

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[302] *Ahmed, S., Nelson, P., Susarla, N., Dees, D. (2018). Automotive Battery Cost Using BatPac. IEA Workshop on Batteries for Electric Mobility. https://www.iea.org/media/Workshops/2018/Session2ShabbirAhmedANL..pdf*

[303] *Anderman, M. (2016). The Tesla battery report: Tesla Motors: Battery technology, analysis of the Gigafactory and Model 3, and the automakers' perspectives. Retrieved from http://www.totalbatteryconsulting.com/industry-reports/Tesla-report/Extract-from-the-Tesla-Battery-Report.pdf*

Anderman, M., (2018, June). The xEV Industry Insider Report. Retrieved from https://totalbatteryconsulting.com/industry-reports/xEV-report/Extract-from-the-2018-xEV-Industry-Report.pdf

Anderman, M., (2018). Progress in EV-Battery Cell Cost and Performance: How Far and How Fast?. SAE Hybrid Vehicle Symposium. Retrieved from http://www.pvsheridan.com/SAE-2018/2.30%20pm%20-%20Menahem%20Anderman,%20Total%20Battery%20Consulting.pdf

Berckmans, G., Messagie, M.,, Smekens, J., Omar, N., Vanhaverbeke, L. & Van Mierlo, J. (2017) Cost Projection of State of the Art Lithium-Ion Batteries for Electric Vehicles Up to 2030. Energies 2017, 10(9), 1314. Retrieved from http://www.mdpi.com/1996-1073/10/9/1314

Davies, C., (2017). VW I.D. EV boast: We'll hugely undercut Tesla's Model 3 says exec. Retrieved from https://www.slashgear.com/vw-i-d-ev-boast-well-hugely-undercut-teslas-model-3-says-exec-17491688/

Holland M., (2018). Tesla aiming to break $100/kwh at cell-level later this year. https://evobsession.com/tesla-aiming-to-break-100-kwh-at-cell-level-later-this-year/

Lienert, P, & White, J. (2017). GM races to build a formula for profitable electric cars. Retrieved from https://www.reuters.com/article/us-gm-electric-insight/gm-races-to-build-a-formula-for-profitable-electric-cars-idUSKBN1EY0GG

UBS. (2017). UBS evidence lab electric car teardown: Disruption ahead? Retrieved from https://neo.ubs.com/shared/d1ZTxnvF2k/

[304] *The origin in Figure 1 represents the most common medium sized car (MedCar) in the model's 2016 baseline. Such a vehicle already has low friction lubricants and engine friction reduction (LUBEFR), variable valve timing (VVT), 6-speed automatic transmission (AT6), 5% mass reduction (MR1), and 5% aerodynamic drag reduction (AERO5).*

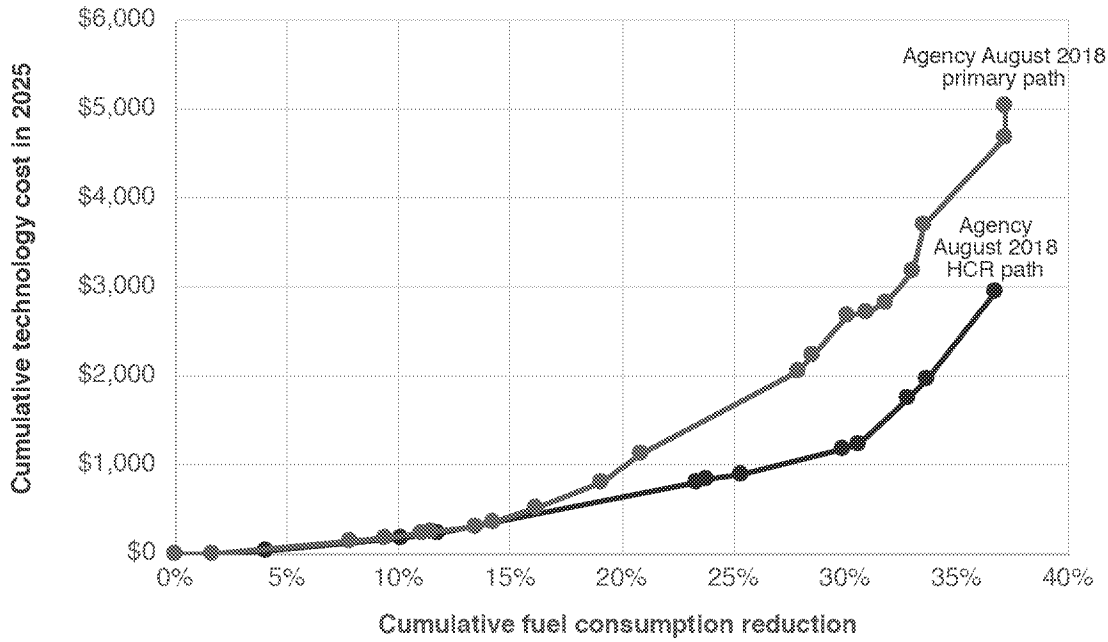

Figure 4. Primary technology paths taken by the medium sized technology class in the CAFE model

As Figure 4 shows, the two technology paths and especially the agency primary path do not follow a smoothly increasing curve where each successive technology has lower cost-effectiveness than its predecessor (i.e., with a higher slope from one point to the next). Rather, there are several points where the slope indicating highly cost-effective technologies are being chosen *after* less cost-effective technologies. If the model reflected the real world and an appropriate regulatory impact assessment, the model would project that the auto industry would choose the most cost-effective technology first, and the lines would have continually increasing slope. Even these sporadic chart lines are merely simple illustrations of the flaws in the agencies' technology paths. As indicated in the comments above there are many more anomalous, erroneous, and inappropriate technology constraints that the agencies have chosen to integrate in their modeling algorithms.

Figure 5 compares the agencies' August 2018 (NPRM) projection of total technology costs for compliance with EPA's original 2016 Proposed and 2017 Final Determination. This shows that the agencies have dismissed (largely without explanation or justification) much of the existing 2016-2017 technical work on the efficiency technologies, and adopted inappropriate modeling constraint on technology deployment the result of which is to artificially push automakers into very high cost technology paths in the compliance modeling of the Augural standards. The figure also shows the ICCT's total technology cost estimates from 2017, which feature more up-

to-date estimates of cost and effectiveness than even the TAR.[305] And even more technology has been developed since ICCT's 2017 assessment, which further lowers the cost to comply with the standards.

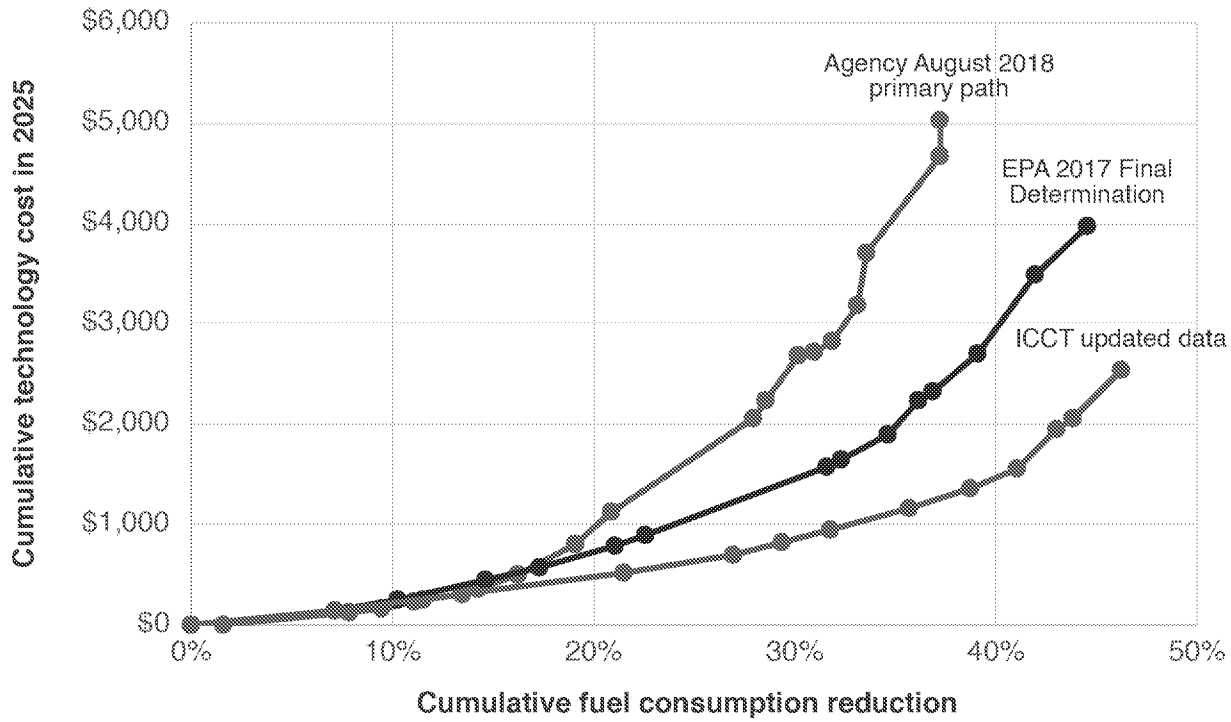

Figure 5. Comparison of the primary medium-sized car pathways in the NPRM, EPA Proposed/Final Determination, and ICCT

For the same level of maximum fuel consumption reduction assumed by the agencies, EPA's own cost projections from the TAR are $2,700 lower, and ICCT's are $3,600 lower.[306] In other words, to achieve the fuel consumption improvement required by the Augural standards, the agencies' new 2018 cost is 100% higher than the EPA 2016 cost. These findings are corroborated by EPA's data analysis, as shared in interagency emails. NHTSA's inputs lead to the application of technology packages that are $1,000 to $2,000 more costly than the most

[305] *Nic Lutsey, Dan Meszler, Aaron Isenstadt, John German, Josh Miller. Efficiency technology and cost assessment for U.S. 2025–2030 light-duty vehicles. March 22, 2017 https://www.theicct.org/publications/US-2030-technology-cost-assessment Note that EPA and ICCT cost curves have been shifted to align with the baseline in the Agencies' August 2018 primary path. The origin of the EPA and ICCT curves represents a vehicle with LUBEFR, electric power steering, aerodynamic drag reduction, low drag brakes, VVT, 6-speed automatic transmission, 10% mass reduction, and 10% reduction in rolling resistance. In the cited paper, this point corresponds to the first technology package applied to a baseline vehicle with no technologies.*

[306] *Id.*

cost-effective packages.[307] And the ICCT updated cost estimate is 35-45% lower than EPA 2016. Based on this, the agencies' 2018 rulemaking appears to effectively have technology costs that are 3.5 times the cost of ICCT's estimated cost to achieve compliance with the Augural 2025 standards. But the EPA 2016 and ICCT 2017 curves are based on more up-to-date data and analysis, including consideration of the most recent automotive technology deployment developments as described above. And this is the result for only one major, high volume vehicle segment (medium-sized cars). Our assessment of other vehicle classes appears to be consistent with this one example.

As with technology effectiveness and deployment, discussed earlier, there are many cases identified in this section where the estimate of technology costs is contrary to the best evidence and to real world adoption of the technologies. There are also several cases where the modeling results show a clear lack of logic in the choice of technologies, by choosing a lower cost effective technology before a higher cost effective technology. However our objections to the invalid assignment of technology costs and to improper modeling are not limited to these specific instances. The agencies need to identify each and every technology cost input used in their modeling, and provide a clear engineering and evidence based justification for why that cost differs from the costs employed in the extremely well documented and well justified Draft TAR and in EPA's 2016 TSD and 2017 Final Determination, taking into account the above discussion of significant new evidence developed since those prior estimates were made. Absent such disclosure and justification, the default assumption needs to be that the prior costs estimated based on the most recent data are more appropriate than the estimates used for the proposal.

D. Summary of data and methodological issues

The technology for compliance with the standards is developing as or more quickly and cost-effectively as predicted in the agencies' past analyses. There are many technical paths to comply with the 2025 standards using only combustion technology. Automaker innovation is outpacing what the agencies projected in 2012, and the costs for compliance appear to be similar or lower than originally projected.

1. Removal of or rejection of pertinent data in rulemaking.

In both EPA's Proposed and Final Determination and the draft Technical Assessment Report and TSD for the midterm evaluation of the 2022-2025 fuel economy and GHG standards, the agencies conducted a massive amount of work to update the technologies and the technology cost and effectiveness assessments since the 2017–2025 rulemaking. The new NPRM and PRIA analysis ignores, suppresses, dismisses, or restricts its use. In summary, these omissions include removal of existing efficiency and GHG-reduction technologies; not using available

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[307] *"Email 5": Email_5_-_Email_from_William_Charmley_to_Chandana_Achanta_-_June_18,_2018. https://www.regulations.gov/document?D=EPA-HQ-OAR-2018-0283-0453. Page 104 "Using the NHTSA inputs, as provided, manufacturers are projected to apply, on average, technology packages that are $1,000-$2,000 more costly than the most cost-effective packages."*

results from state-of-the-art vehicle simulation modeling; not using available industry-leading and peer-reviewed engineering teardown studies; not using the most recent estimates of technology cost and effectiveness; failure to include multiple technologies already in production or for which production phans have been announced; and ignoring recent work performed and data gathered by EPA. The agencies fail to clearly identify all of the many technologies and technology packages where they have changed their position on technology cost or effectiveness, and explain and justify the basis for the change.

We also emphasize two findings. First, in the Draft TAR and Final Determination, EPA observed the real-world advances toward production vehicles using HCR2 technology, and determined that that technology could be adopted by automakers during the compliance period. In the draft TAR, without rational explanation, the agencies now describe this technology as "speculative" and have omitted the technology from their primary compliance scenarios altogether. This is a dramatic change, as the agencies' own sensitivity run allowing HCR2 technology to be used reduced compliance costs by over $610. This single technology reduces the compliance cost for the augural standards to $1,292, on par with NHTSA and EPA estimates in the TAR. And this is only one example - there are many other examples in the NPRM of technologies that are not allowed or for which use is constrained without rational justification.

Second, the agencies have adopted estimated costs for individual technologies that lack real-world support. For example, the 2019 RAM 1500 pickup truck offers a 48V BISG hybrid system as a stand-alone option, which offers a real world comparison to the estimates in the NPRM. The NPRM estimates for adding a BISG system to a pickup truck were an efficiency improvement of 5.7% at a manufacturing cost, without the retail price increase, of $1,616. This results in a cost of $284 per 1% efficiency improvement. In comparison, the BISG system on the 2019 RAM pickup costs $1,450, which, after factoring in the 1.5 RPE markup, yields a manufacturing cost of $967. Official fuel economy values from fueleconomy.gov show that BISG on the RAM improves efficiency by 10.1% on the 2wd version and 10.3% on the 4wd version, for an average cost of $95-per-one percent efficiency improvement – just a third of that modeled in the NPRM. But this does not include the performance, drivability, and utility benefits of the BISG system realized on the RAM as well (meaning that the technologies' full potential was not realized in efficiency gains alone). As Fiat-Chrysler calls this system eTorque, it suggests that these other benefits are valuable to their customers. Roughly assuming half cost is properly assigned to these other consumer benefits (and thus the full efficiency potential is approximately double what was realized), the cost-per-one percent efficiency improvement drops to less than $50, or about a sixth of the NPRM estimates. These two examples illustrate how much the agencies have ignored, suppressed, dismissed, and restricted data and inputs for the NPRM.

2. Changes since the Draft TAR, TSD, and Final Determination

The agencies have created a new system of handling technology inputs and dismissed the older system that underpinned all the GHG regulations. However, the agencies have not justified and explained their choices to reject the vast amount of research and information gathered by the

agencies during the midterm evaluation prior to the Proposed Rule. For example, as a result of the new model and inputs, we find the following issues:

- Largely without explanation, EPA abandoned its use of its superior engine maps, ALPHA simulation, and OMEGA fleet modeling tool, and thereby also abandoned its efficiency, availability, technology cost, and compliance cost estimates. The agencies instead used NHTSA's inferior IAV-Autonomie-CAFE modeling system, and inadequately analyzed compliance scenarios for the EPA Greenhouse Gas Emission program.
- EPA abandoned its use of its superior engine maps based on benchmarked high efficiency engines, and instead uses NHTSA's outdated engine maps.
- Without explanation, EPA abandoned its use of its superior ALPHA vehicle simulation modeling which has a better and more proven track record in handling technology combinations. Instead the agencies are relying on a less vetted Autonomie tool that struggles to handle engine-transmission synergies and suffers from older engine maps and lack of updating from the latest automotive powertrain developments.
- HCR costs went up (from EPA's values), ADEAC cost went up, GDI costs went up, CEGR1 costs went up, turbocharging (and turbocharged downsizing) costs went up, complete strong hybrid vehicle costs went up, and battery costs went up. Further cost increases may yet be undiscovered.
- The agencies buried mass reduction, low rolling resistance tires, aerodynamic improvements, electric power steering, improved accessories, and low-drag brakes into the baseline fleet. With these baseline shifts, the agencies, without acknowledgement, made dramatic updates to the technologies deemed to have been applied in the baseline fleet, without any real-world justification for doing so. Doing this removes technology for later use, and artificially pushes companies to adopt more costly technology.
- The agencies abandoned their previously-used indirect cost multiplier method for estimating total costs (which was vetted with peer review, and more complexly handled differing technologies with different supply chain and manufacturing aspects) in favor of only using a retail price equivalent (which crudely assumes all technologies have a 50% markup from the direct manufacturing technology cost).
- CEGR1 was revised to have an efficiency level of 0%, but the agencies imposed the technology on the fleet anyway.
- EPA removed HCR2 technology and instead the agencies studied the technology as a sensitivity case (which showed that it greatly reduced compliance costs).
- The agencies have adopted the assumption that automakers cannot apply numerous technologies unless they were already applying them in model year 2016 (HCR for all companies that have not applied it in 2016; various individual technologies and technology combinations on a given model—by-model basis depending on their technology baseline in 2016)
- The agencies have adopted the assumption that certain technologies cannot be applied together (e.g., Turbo-DEAC; HCR1-DEAC; HCR1-CEGR)
- The agencies have removed Miller Cycle as an available technology

- The agencies reduced their effectiveness estimates for stop-start and mild hybrid technology
- The agencies reduced their effectiveness estimates for 7-, 8-, 9-, and 10-speed transmissions, and specifically assign advanced 10-speed transmissions a *negative* value compared to advanced 6-speed transmissions
- The agencies reduced their effectiveness estimate for dual clutch transmissions, and specifically assign 8-speed dual clutch transmissions a *negative* effectiveness value compared to 6-speed dual clutch transmissions
- The agencies have removed any analysis of the availability, cost, or cost-effectiveness of the refrigerant HFO-1234yf, which previously was capable of very cost-effectively delivering GHG benefits of up to 13.8 g/mile (cars) and up to 17.2 g/mile (light trucks).
- The agencies have removed analysis of automakers' ongoing efforts to adopt air conditioning technology, the cost-effectiveness of those technologies compared to other technologies, and have failed to even describe the lost benefits from the substantial removal of GHG benefits (up to 40% of GHG reductions from the adopted 2021-2025 standards) that would result.
- Overall, EPA has doubled its compliance cost estimates, based primarily or entirely on modeling changes, without real-world justification.
- Overall, NHTSA has increased its compliance cost estimates by approximately 50%-100% (depending on the precise summary cost numbers from the rulemaking documents), based primarily or entirely on modeling changes, without real-world justification. In the TAR, NHTSA estimated 2025 technology costs to comply with the augural standards would be $1,161 and EPA's estimated costs were $894, dropping to $875 in the Final Determination. Yet, despite new technology developments that improve efficiency at lower cost, the agencies have increased the compliance cost to $1,908. A clear summary of the causes for this massive increase in cost are not directly addressed in the NPRM, suggesting that the agencies know that the cost increase cannot be justified by any real and updated data that has newly arisen from their NPRM research.

3. Summary of errors in rulemaking analysis

The agencies' development of artificial and incorrect manufacturer constraints, construction of erroneous technology packages, and use of fundamentally flawed fleet modeling leads to results that do not reflect least-cost compliance.

The model's approach to limiting technology availability and constraining manufacturers does not reasonably reflect the real-world choices made by automakers and suppliers to develop and proliferate cost-effective technology. Technology is available for all manufacturers as the methods of improving vehicle fuel consumption and reducing emissions are well-known, as discussed and referenced above. Additionally, the model fails to correctly capture the rate at which technologies can penetrate the fleet through manufacturer product refresh and redesign cadence, which results in new technology introduction by each company at a faster rate than the agencies are suggesting (See Table 3). Due to the model's flawed algorithms, structure, and

hard-coded constraints, the model's use leads to bizarre technology applications and combinations that grossly inflate the costs of compliance.

Compounding these flaws are the methodological errors used in vehicle modeling. Outputs of the model indicate that technology packages do not follow the most cost-effective paths, nor are vehicles and fleets truly optimized. Slight changes in technology effectiveness and cost inputs, along with constraints in technology availability, result in dramatically increased costs of compliance. By using outdated data and ignoring recent updates and innovations, the agencies developed technology packages that are incorrectly less effective and more expensive. By the agencies' analysis, some technologies have negligible effectiveness, yet significant cost, and explicably are widely deployed in future year standards. The agencies also did not explicitly model or attempt to estimate costs for several applicable technologies, for example: e-boost, variable compression ratio, Miller cycle, gasoline compression ignition, cooled EGR on naturally aspirated engines, and cylinder deactivation on advanced engines. Though the agencies are always going to be somewhat behind in their assessments of potentially promising technologies due to data availability constraints, the assessments in the NPRM are woefully and unjustifiably deficient. We emphasize that the single most important factor in the accuracy of costs and benefits for projections is the use of the latest, most up-to-date technology data and developments. Using older data guarantees that the cost of meeting the standards will be overstated, as it does not include more recent technology developments and thus defaults to more expensive technology, such as full hybrids, the costs of which are themselves greatly exaggerated. Assuming that the end of innovation has been reached and basing projections on what was in production in 2016, which the agencies have essentially done, ignores technology developments that have been achieved since then and developments in process, and this invalidly overstates the cost of future compliance.

The agencies' technical analysis for the proposal fails to use the best evidence available and uses improper constraints on technology and its deployment. There is clear evidence of numerous cases where the inputs to the model on cost, effectiveness, and technology deployment are improper, and clear evidence of significant cases where the model produces illogical and invalid results. There are unexplained adjustments to the baseline technology, without evidence to support the change and inconsistent with the fleet average performance for recent years. For each technology, technology package, and modeling constraint there is a systematic failure to identify the estimate or choice the agencies made in the 2012 rulemaking and Mid-Term Evaluation, the evidence and reasoning underlying that prior estimate or choice, the changes made for this proposal, and the evidence and reasoning justifying this change. Overall this reflects a failure to properly develop, do quality control on, and vet the model and its inputs, and a failure to conduct reasoned and decision making. The result is a proposal that significantly overestimates the cost and underestimates the cost-effectiveness of compliance, for the current standards as well as for various alternatives.

II. Cost-benefit methodology

In this section we provide comments in areas of the rulemaking related to how the agencies have conducted their cost-benefit analysis. Overall we find their cost-benefit analysis to be an unusual and novel approach that we have not seen before in U.S. regulations or elsewhere around the world. The agencies' new alterations in their analysis include creating a new approach to adopt technology into a baseline fleet in the absence of stronger standards, adopting a method that suggests consumers do not value fuel economy, to projecting lower sales of new vehicles and more driving and fatalities in older vehicles, and finally combining all their new costs and benefits to suggest that decreasing fuel economy will produce net societal benefits. We summarize our comments on the agencies' new analysis in the sections below.

A. Baseline dynamics

The agencies have made an inappropriate decision to artificially reduce the regulation benefits and increase the estimated costs of the current standards by adjusting their vehicle fuel economy and GHG emissions baseline fleet. Here we use the term "baseline fleet" to refer to the projected fleet under the agencies' proposed rollback scenario (that is, their projections of achieved mpg and GHG emissions levels in the absence of increasingly stringent standards over time). The agency decision to assume a continually improving fuel economy baseline in the absence of standards is new, misrepresents all available historical evidence, and shows the agencies are not utilizing the agencies' own extensive analysis and data on this topic.

There is a long history with clear data to inform this decision about how to treat baseline fuel economy when standards are not increasing. The data clearly and unambiguously demonstrate that when fuel economy or GHG standards do not get more stringent, new vehicle fleet-wide fuel economy will not increase and GHG emissions will not decrease. Because it appears that the agencies are not drawing upon their own data, which provides a rich historical record, we present the applicable official EPA data in Figure 8 below. As depicted, the periods where fuel economy and GHG standards require improvement, improvements in test cycle fuel economy occur. On the other hand, the period where standards did not get more stringent, from 1986 through 2004, no fuel economy and GHG benefits are evident. With the adoption of California's GHG standards in 2004 (for model years 2009-2016), and NHTSA light-truck fuel economy standards in 2002 (for model year 2005), fuel economy improvements resumed.

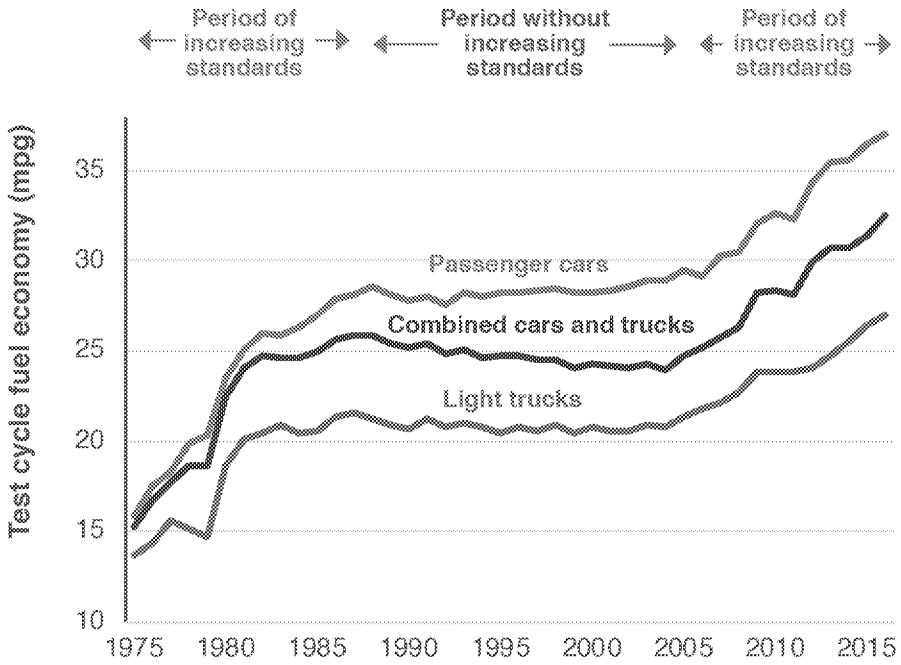

Figure 6. Test cycle fuel economy 1975 through 2016 based on official EPA data[308]

This phenomenon has been very well studied in the technical literature. What happens during periods without fuel economy improvement is that the industry deploys technology to make higher-power, greater-acceleration, and larger vehicles[309]. The agencies' expert staff that handle and analyze this data know that this is the case, as they have a robust 45-year record in the EPA fuel economy trends database, and comparable NHTSA data that is derived from EPA's official compliance data from the entire auto industry. We note that, from the ICCT extensive analysis elsewhere around the world the same general result is true.[310] The only times we have observed any real-world fuel economy or CO_2 improvements in the absence of regulations are in European markets where fuel prices are several dollars higher per gallon than in the U.S., and when automakers had instituted voluntary CO_2 targets in lieu of standards for new 2010 passenger vehicles. This ultimately led to Europe developing CO_2 regulations to ensure verifiable emission reductions occurred.[311]

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[308] *Environmental Protection Agency. The Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends Report. https://www.epa.gov/fuel-economy-trends*

[309] *Environmental Protection Agency. The Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends Report. https://www.epa.gov/fuel-economy-trends. Nicholas Lutsey and Daniel Sperling, 2005. Energy Efficiency, Fuel Economy, and Policy Implications. Transportation Research Record: Journal of the Transportation Research Board. Volume: 1941 issue: 1, page(s): 8-17*

[310] *The ICCT analyze aspects of global CO_2 and efficiency standards, which are in place where approximately 80% of the world's light-duty vehicles are sold. See https://www.theicct.org/chart-library-passenger-vehicle-fuel-economy*

[311] *See International Council on Clean Transportation. European vehicle market statistics, 2017/2018. (November 28, 2017) Ed Peter Mock. https://www.theicct.org/publications/european-vehicle-market-statistics-20172018.*

Despite this history, the agencies have made a novel decision to assume that the fleet sees improved fuel economy and GHG emissions even when standards are flat, as in the agencies' proposed rollback of standards for 2021 and beyond. In the NHTSA CAFE analysis of its Augural 2022-2025 standards, the agencies project that fleet would see improved GHG emission levels of 201 g/mile (on the test cycle) in 2025.[312] The proposed rollback would keep the GHG standards at about 241 g/mile for 2021-2026.[313] The novel conclusion of the agencies in this NPRM was to project that the fleet, under the proposed regulatory freeze from 2021 on, still would realize a real-world GHG reduction down to 232 g/mile - thus beating the standard by nearly 10 g/mile. As shown above, the historical record for fuel efficiency certainly does not back this assertion. The result of the agencies unfounded adjustment in the baseline is that the agencies have artificially removed 22% of the GHG and fuel saving benefits that would result from maintaining the adopted 2025 GHG standards and the Augural 2025 CAFE standards. The decision to assume an increasing efficiency under the rollback also has a presumably inconvenient result for the agencies: It directly contradicts the agencies' claim that their proposed 2026 standards are the "maximum feasible" and should remain flat from 2021 on.

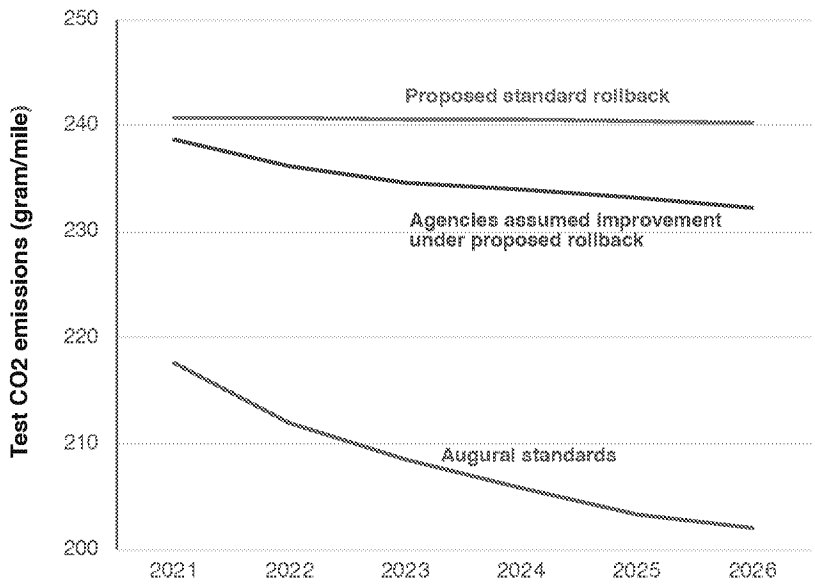

Figure 7. Estimated CO_2 emissions for proposed rollback standards, agencies' assumed improvement that occurs with the rollback, and Augural 2021-2025 standards under CAFE scenarios.

[312] Outputs from NHTSA datafiles. National Highway Safety Traffic Administration, 2018, "Compliance and Effects Modeling System." https://www.nhtsa.gov/corporate-average-fuel-economy/compliance-and-effects-modeling-system

[313] *83 Fed. Reg. at 42989, Table I-3*

B. Fleet rebound, vehicle activity, and safety

The switch to footprint-based CAFE and GHG standards has been widely credited with diminishing safety concerns with efficiency standards. Footprint standards encourage larger vehicles with wider track width, which reduces rollovers, and longer wheelbase, which increases the crush space and reduces deceleration forces for both vehicles in a two-vehicle collision. Despite the compelling record on this issue, the agencies project relatively large increases in traffic fatalities, over 1000 per year, for the augural standards for model years 2021 through 2026. These projected additional fatalities are used as a basis for freezing the CAFE and GHG standards for model years 2021 through 2026. The agencies' finding is in direct opposition to U.S. trends, which show improvements in both vehicle efficiency and safety driven by government policy.

1. Vehicle fuel economy and safety background

Vehicle fuel economy and safety have improved remarkably. Figure 8 compares annual highway fatalities per 100 million miles[314] and the in-use fuel economy (mpg) of all cars and light trucks on the road[315] in the U.S. from 1970 to 2015. The trends show reasonably steady increases in in-use fuel economic and decreases in fatalities per 100 million miles for 35 years. In fact, the period from about 1980 to 1990 has simultaneously some of the steepest increases in fuel economy and decreases in fatalities. A simple linear regression of fatalities per 100 million miles as a function of in-use fuel economy has an r-squared of 0.93. These suggest that, statistically, higher in-use fuel economy has been strongly correlated with lower fatalities, contrary to the claims of the agencies. Of course, there are a multitude of driver, road, and vehicle safety technology factors that affect fatalities that might be correlated with fuel economy.

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[314] *Traffic Safety Facts 2015, DOT, NHTSA, 2017 Edition, Chapter 1, Table 2. https://crashstats.nhtsa.dot.gov/Api/Public/Publication/812384*

[315] *Transportation Energy Data Book, Edition 36.1, Released April 30, 2018 by Oak Ridge National Laboratory, Table 4.3. https://cta.ornl.gov/data/tedbfiles/Edition36_Chapter04.pdf*

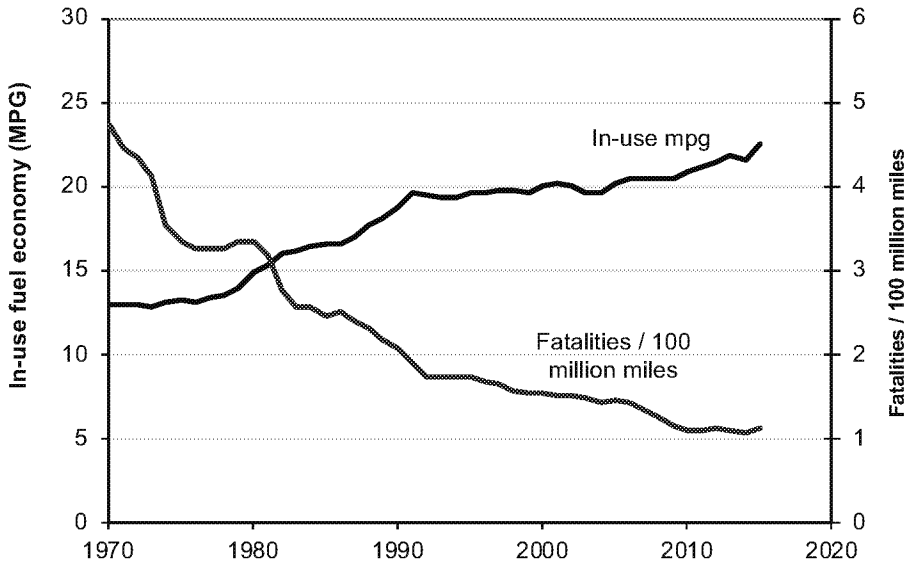

Figure 8. 1970-2015 U.S. highway fatalities per 100 million miles and in-use fuel economy

Comparing new vehicle fuel economy with crash test results offers a more direct comparison of the efficiency and safety of individual vehicles. Figure 9 compares average new car and new light truck fuel economy (mpg)[316] with results from five different crash tests conducted by IIHS on model year 1995 to 2018 vehicles.[317] The proportion of vehicles that were rated "good" in IIHS's moderate overlap, side impact, head constraints/seats, roof strength, and small overlap crash tests are plotted individually. The rapid rise in the proportion of new vehicles rated "good" in each of the crash tests reflects both an increase in the number of vehicles tested by IIHS using the new test as well as automakers adapting their designs to address the problems highlighted by the test when it was brought on line. While the lower proportion of vehicles tested in the first year or two after a new test is introduced contributes to the rapid increase in the number of vehicles rated "good", it is still clear that manufacturers are rapidly responding to the new crash tests with robust safety designs, regardless of the absence or present of new vehicle CAFE and GHG standards. In fact, manufacturer response to the moderate overlap crash test introduced by IIHS in 1995, a period when efficiency standards were not changing, was slower than manufacturer responses to new crash tests after introduction of efficiency requirements.

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[316] *ICCT Global Passenger Vehicle and Light Truck mpg, https://www.theicct.org/sites/default/files/Global_PV_figure_data_20180406.xlsx*

[317] *IIHS personal communication. And IIHS crashworthiness evaluation programs and the U.S. vehicle fleet — a 2017 update. Highway Loss Data Institute Bulletin Vol. 34, No. 18 : September 2017*

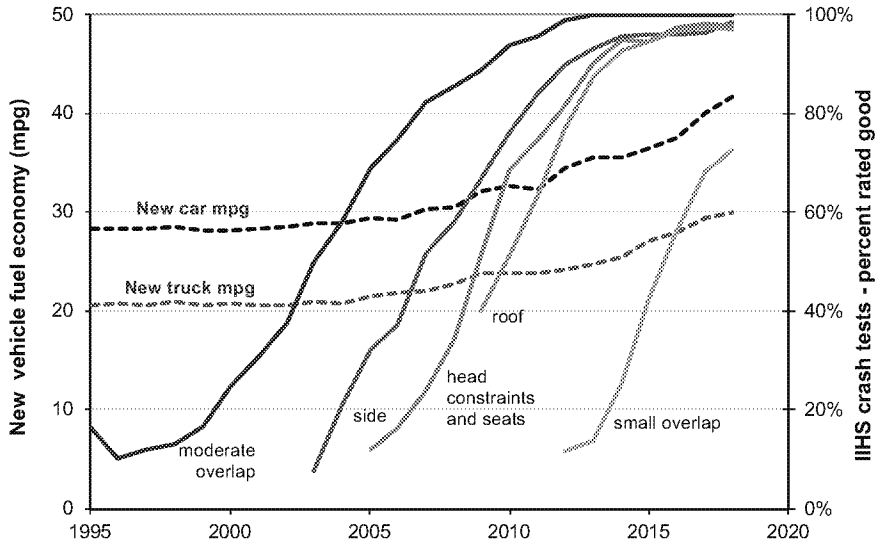

Figure 9. New vehicle (car and light truck) fuel economy (mpg) and proportion of vehicles rated "good" in IIHS crash tests

The positive trends in both fuel economy and safety were driven by government regulations. The large majority of the fuel economy and GHG reductions required by government regulations are achieved with powertrain technology. Prominent examples include downsizing engines for better efficiency while maintaining performance with turbocharging, improved transmissions and additional gear ratios, higher compression ratio for higher efficiency, Atkinson cycle engines that extract more useable work from combustion, and hybrids. But these are just the major steps – there are a host of other technologies that also improve efficiency. In addition, there are improvements in aerodynamic design to reduce drag, reductions in tire rolling resistance, and higher efficiency accessories and pumps. None of these affect safety in any way. Among the technologies, lightweighting sometimes receives added scrutiny, but the agencies have pointed out it does not have a statistically significant effect on safety.[318]

In 2007, NHTSA chose to adopt size-based adjustments instead of weight-based adjustments because they promote better safety design. Footprint standards encourage larger vehicles with wider track width, which reduces rollovers, and longer wheelbase, which increases the crush space and reduces deceleration forces for both vehicles in a two-vehicle collision. Support for the negligible impact of footprint-based standards on safety is widespread:

- In the 2012 rulemaking adopting 2017-2025 standards, EPA and NHTSA concluded that "the standards should not have a negative effect on vehicle safety as it relates to vehicle size and mass."[319]

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[318] *83 Fed Reg. 43111. "None of the estimated effects have 95-percent confidence bounds that exclude zero, and thus are not statistically significant at the 95-percent confidence level."*

[319] *Joint Technical Support Document of the 2012 original 2017-2025 rule at 2-2*

- The safety analysis in the 2016 joint EPA/NHTSA Draft TAR found, "small net fatality decreases over the lifetimes of MY2021-2025 vehicles."[320]
- The 2015 NAS study that reviewed the 2017-2025 standards found that "the empirical evidence from historical data appears to support the argument that the new footprint-based standards are likely to have little effect on vehicle safety and overall safety."[321]
- The Insurance Institute for Highway Safety has said "The Obama-era changes to the rules, essentially using a sliding scale for fuel economy improvements by vehicle footprint, addressed safety concerns that IIHS raised in the past."[322]
- Automakers themselves have noted, they are "increasingly using lightweight materials to help meet greenhouse gas (GHG) and fuel economy standards without having to sacrifice the safety and performance of their vehicles."[323]
- The head of the Alliance of Automobile Manufacturers stated during testimony, "The auto industry invests more than $100 billion annually in research and development to improve vehicle fuel economy and safety, and this investment is paying off as vehicles on the road today are safer, cleaner, and more fuel-efficient than ever before."[324]

It is clear that, as designed, footprint-based systems remove incentives to build smaller cars that might be less safe. Thus, fuel economy and GHG standards have no measurable impact on safety. In fact, no country or region in the world other than the U.S. has raised concerns about their fuel economy or CO_2 standards affecting vehicle safety.

Looking forward, there are important synergies between efficiency and safety, and major areas of potential improvement that continued from the recent positive trends. High-strength steel, aluminum, and carbon fiber are increasingly employed in new vehicle designs not just because they are lighter and help comply with fuel economy and GHG standards, but because they have better crash properties than conventional steel and help improve NCAP scores. This is not reflected in NHTSA's current vehicle safety analyses, which are based upon historical data (the newest vehicles in NHTSA's current crash data set date from model year 2011).

2. *Two tricks being used to artificially create fatalities*

The agencies falsely claim that rolling back the CAFE and GHG Standards will reduce traffic fatalities. The reductions in projected fatalities discussed by the agencies are not related to changes made to cars and trucks under the CAFE and GHG standards. The agencies claim

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[320] *Draft TAR at 8-61*

[321] *National Research Council, Cost, Effectiveness, and Deployment of Fuel Economy Technologies for Light-Duty Vehicles (Washington, DC: National Academies Press), 2015. doi:10.17226/21744. (see p. 13, specifically).*

[322] *Safety Gains From Heavier Cars May Be Cited to Cut MPG Rules. Bloomberg. February 12, 2018. https://www.bloomberg.com/news/articles/2018-02-12/safety-of-heavier-cars-may-be-used-to-lower-u-s-fuel-efficiency*

[323] *Joint statement of the Association of Global Automakers and the Alliance of Automobile Manufacturers, Jan. 21, 2016, available at: https://autoalliance.org/2016/01/25/car-vehicle-lightweighting-study-provides-good-insight-on-automakers-efforts-to-increase-ghgfuel-economy/).*

[324] *House Energy and Commerce Committee Hearing, Mitch Bainwol Witness Statement, Sept. 22, 2016, available at: http://docs.house.gov/meetings/IF/IF17/20160922/105350/HHRG-114-IF17-Wstate-BainwolM-20160922.pdf*

fatalities result from more stringent standards because, with the standards, Americans voluntarily decide to drive more. Effects like these cannot reasonably be attributed to standards that make vehicles lower polluting and more fuel efficient. Otherwise, anytime we have policies or programs to invest in our roads and highways or make cars more accessible by improving financing, the associated driving—and any related accidents—would have to be evaluated from a cost-benefit analysis perspective on those programs. Of course we do not do that.

The agencies are using two different tricks to falsely justify a future increase in modeled driving ("vehicle miles traveled" or VMT) under the standards—and then they use the increased driving projections to argue that vehicle accidents and fatalities will increase under the adopted GHG and Augural CAFE standards.

The first trick is that the proposed rule doubles the rate used to calculate the "rebound effect" from the rate used in prior analyses from 10% to 20%. The rebound effect is used to estimate how much more individuals drive a car that is more fuel efficient and therefore cheaper to drive relative to a car that is less fuel efficient and more expensive to drive. By doubling the rebound rate, the agencies can claim that under the augural standards Americans who buy more fuel-efficient cars will drive those cars much more because they are cheaper to drive.

This doubling of the rebound effect is in contradiction to both theory and data trends. The rebound effect is not fixed. Vehicle owners adjust how much they drive based upon how much they value their time and the marginal cost of driving. The value of time goes up as disposable income increases, such that economic growth causes owners to value the time necessary to drive more highly and making the fuel-cost of driving relatively less important, thus decreasing the rebound effect. Similarly, improving vehicle fuel economy decreases the marginal cost of driving, making any further reductions in fuel consumption relatively less important and decreasing the rebound effect. Small and VanDender wrote the first report discussing and analyzing these trends.[325]

Most studies are based upon changes in fuel price, not changes in vehicle efficiency, and limited data suggest that customers respond more strongly to changes in fuel prices. Thus, studies based upon fuel price overstate the rebound effect. Limited data also suggest that customers respond more strongly to increases in the cost of fuel than to decreases, also overstating the rebound effect for reductions in vehicle fuel consumption. Finally, more recent studies tend to support that the rebound effect has been decreasing over time.

The agencies' evaluation of the rebound effect in the 2016 TAR appropriately considered these effects and, found that the best available data supported a 10% rebound effect. However, the NPRM reverses course and ignores all of these considerations, giving equal weight to all studies – including studies on non-U.S. market and older studies. Further, note that economic growth is projected to continue into the future and baseline vehicle fuel economy is improving due to standards already adopted for 2011 to 2020. Thus, contrary to the doubling of the

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[325] *Small, K. and Van Dender, K., 2007a. "Fuel Efficiency and Motor Vehicle Travel: The Declining Rebound Effect." The Energy Journal, vol. 28, no. 1, pp. 25-51.*

rebound effect in the NPRM, the rebound effect will continue to decrease in the future and is likely to be well under 10% by 2025.

While the rebound effect is real, owners would not drive more if they did not perceive economic benefits to the additional driving, which include their consideration of the accident risk of driving more. And, in fact, the agencies admit in the NPRM that Americans choosing to drive more, and the accident risks that driving carries, should not affect the analysis of the costs and benefits of the standards, because when people drive more, they do so because they are benefiting from the driving—in their words, it is a "voluntary consumer choice." However, the agencies have chosen to separate the additional accidents from the economic benefit of driving more in the rule, creating an artificial "loss" associated with additional accidents and fatalities balanced by an "economic benefit" of exactly the same dollar value. This allows the agencies to quote the additional fatalities and use them as justification for freezing the standards, while hiding the associated economic benefits (equal in magnitude, in the opposite direction) deep in the details of the proposed rule. Even the agencies admit that exactly offsetting the cost and benefits is insufficient, as they acknowledge that "at a minimum" the real world benefits *exceed* the real world costs.[326]

The second trick is that the agencies have created a new, untested model of used car impacts—which attempts to model something in an entirely new way and which has not been peer reviewed—to look at the effects on the *used* car market of changes in the cost of *new* cars. The NPRM dramatically exaggerates the compliance costs of the current standards relative to the analyses of costs that were completed in 2012 and in 2016. The agencies' exaggerated compliance costs are plugged into their new fleet scrappage model while ignoring the value that consumers place on fuel savings from more efficient vehicles, which results in an increase in the cost of new cars and to a modeled small decrease in new car sales. The modeling also inexplicably projects a dramatic increase in the number of used cars in the vehicle fleet ,and thus a dramatic increase in the total number of vehicles being driven. Even more inexplicably, the model indicates there will be a dramatic increase in how much used cars are driven. The problems in the scrappage modeling, or perhaps at least some of its most glaring flaws, would have presumably been caught if the agencies had conducted a comprehensive peer review and validation of their novel scrappage modeling approach, as was suggested by EPA.[327] However, the scrappage model has not been reviewed and validated since the addition of the scrappage

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[326] 83 Fed. Reg. at 43107 ("[i]f consumers choose to do so, they are making a decision that the utility of more driving *exceeds* the marginal operating costs as well as the added crash risk it entails." (emphasis added)); *id.* at 43,158 ("rebound-related fatalities and injuries [are] . . . offset by societal valuations that *at a minimum exceed* the aggregate value of safety consequences plus added vehicle operating and maintenance costs" (emphasis added)).

[327] *EPA commented ""Many of the policy conclusions of this proposal, especially regarding safety, rely on the new scrappage model's findings. How has the model been reviewed and validated?" See "EO_12866_Review_EPA_comments_on_the_NPRM_sent_to_OMB,_June_29,_2018". https://www.regulations.gov/document?D=EPA-HQ-OAR-2018-0283-0453. Page 161.*

model.[328] It is unclear why the agencies would make such a dramatic, novel, and consequential move within a rulemaking like this, without comprehensive expert scrutiny.

Thus, from the two tricks, the agency modeling in the NPRM projects both *new* and *existing* cars are going to be driven much more if standards continue to be increased (per the adopted 2025 GHG standards and augural 2025 CAFE standards), which defies all logic and economic theory. The error is further compounded because, unlike the rebound effect that the agencies admit is due to consumers voluntarily driving more and is not caused by the standards, the agencies claim this increase in driving is not voluntary consumer choice and the related fatalities are *caused* by the standards.[329] Finally, note that this modeling has never been applied to any of NHTSA's safety regulations (which they also project will add future year costs to new vehicles) – rather it was developed specifically for the 2018 proposed rollback in the CAFE and GHG standards.

This mysterious, incredible increase in driving of existing vehicles biases the cost-benefit analysis of the proposal by as much as $120 billion in reduced fatalities and non-fatal crash injuries. Including the impacts from the associated, alleged reduction in congestion and noise from this driving inflates the agencies' estimated effect by another $52 billion. The agencies are citing these alleged reductions in fatalities and associated effects—from getting Americans to drive less—as the primary reason they need to roll back the CAFE and GHG standards.

For the agencies to put forward a credible final regulation on vehicle fuel economy and GHG regulations, they have no choice but to remove the scrappage-related fatalities and associated costs. If the agencies do not remove the artificial scrappage-related fatalities and associated costs from the regulatory analysis, NHTSA, the nation's vehicle safety regulator, will cast into doubt its own expertise and credibility.

3. *Direct impacts of lightweighting on safety*

The potential direct impacts of weight reduction on safety are extremely small compared to the two factors just discussed, but are discussed here for completeness. NHTSA and other organizations, such as DRI and Lawrence Berkeley National Laboratory, have analyzed the historical impacts of vehicle size and weight for the last 15 years. NHTSA's most recent study, from 2016, is included in the NPRM, using updated data. NHTSA's latest safety analysis results in slightly lower fatalities if weight is reduced while holding vehicle size constant than the previous study from 2012 used in the TAR.[330]

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[328] *CAFE Model Peer Review. https://www.regulations.gov/document?D=NHTSA-2018-0067-0055 See bottom of p. 303. The model was updated to include scrappage after the peer review was conducted*

[329] *The proposed rule claims the additional fatalities are due to older vehicles with less safety features remaining on the road longer, but the vast majority of the additional fatalities are driven by the inappropriate increase in travel.*

[330] *83 Fed Reg. 43111. "None of the estimated effects have 95-percent confidence bounds that exclude zero, and thus are not statistically significant at the 95-percent confidence level."*

In the agencies' assessment of weight reduction and fatalities, the agencies found that any effects of weight reduction and fatalities are not statistically significant at the 95-percent confidence level. This is a positive recognition of where the leading research in the field has been consistent in past years. However, for the proposed rule, the agencies decided to use the results that were statistically not significant, and an assumption that mass reduction is done relatively evenly across vehicle classes and sizes, to suggest that there would still be a small increase in overall fatalities of 160 per year.

This assumption of constant mass reduction for all vehicles is not consistent with historical or projected weight reduction, which has been concentrated primarily in medium to large vehicles and trucks. The Ford F150 aluminum body pickup truck is the primary example. Based on info from the Aluminum Association, it appears that the largest weight reduction is primarily in larger vehicles[331] Using any reasonable assumption about larger weight reduction in larger vehicles, the impact of weight reduction on overall fatalities would likely be slightly positive. Also note that these historical analyses do not fully consider the better crash properties of high strength steel and aluminum compared with conventional steel, which will reduce overall fatalities in the future.

We recommend that the agencies acknowledge that more mass reduction is occurring on larger vehicles and incorporate this development in their modeling. We also recommend that agencies acknowledge their own results regarding how mass reduction is not statistically linked with fatalities, and, as a result, remove any related fatalities (positive or negative) from their regulatory analysis. We also recommend that NHTSA, within this rulemaking, report on their leading research, research from the literature, and automaker developments, on how lightweighting designs that the auto industry is pursuing are positively impacting vehicle crash and crash avoidance properties.

C. Consumer value of technology features

The NPRM continues a long-standing error of failing to consider technology benefits that are valued by consumers, in addition to the efficiency benefits. This failure is becoming more glaring over time, as technology deployment continues to add more attributes consumers are willing to pay for. The most common benefit is improved performance and drivability, but many technologies also offer other benefits.

1. Transmission gears.

Adding more gears to the transmission improves maximum acceleration by keeping the engine closer to its maximum power output, improves launch feel due to lower gear ratio in first gear, reduces noise on the highway by running the engine at lower speed, and reduces vibration and harshness by reducing the change in engine speed between shifts. Magazine reviews include the following—

[331] *https://www.drivealuminum.org/wp-content/uploads/2018/08/Mass-Reduction-Chart.pdf*

- Ford F150. "For the ever-critical towing aspect of trucking, the 10-speed doesn't disappoint. We drove a 2017 F-150—with a big dual-axle trailer that Ford claimed amounted to 9900 pounds of ballast—back to back with a 2016 model with the same load. Although we can't speak to the V-6's power advantage over its predecessor, the 10-speed holds a clear edge. Its extra ratios afford more options when downshifting, such as when descending a steep grade, and the shifts are even rev matched in Tow/Haul mode for maximum smoothness. The six-speed, by comparison, is slower to shift and feels lumpier when selecting a lower gear; it can also be caught out trying to choose among gears."[332]
- Ford Mustang. "The new 10-speed auto is one thing that doesn't need fixing on the street. On our favorite roads, it was perfect. Even with its software update, the EcoBoost still runs out of breath at high rpm, but you wouldn't know it because this transmission knows exactly how to use all its gears to keep the engine in the meat of its power. That includes both shifting at the horsepower peak and downshifting under braking so you're right at the torque peak when you're ready to accelerate out of the corner."[333]
- Chevrolet Camaro. "One of the most stand-out features of Chevy's brutish Camaro ZL1 is its optional 10-speed automatic transmission. The gearbox, also found in the 2017 Ford F-150 Raptor, was able to help get the ZL1 around the Nurburgring in a blistering 7:29.6." "What's interesting is just how much spacing there is between some of the gears. Through the first six gear ratios, every gear is very closely spaced, clearly aimed for maximum power output and performance. But as the car shifts into seventh, the RPMs drop significantly, indicating that gears seven through ten are optimized for economy driving. It's like having a close-ratio racing gearbox and an economy-minded transmission all in one."[334]
- Honda Accord. "When the Accord's new 2.0-liter engine is paired with the 10-speed automatic, it's a few tenths of a second quicker to 60 mph than the outgoing V-6 despite its lower horsepower rating. It takes only 5.5 seconds to zip from zero to 60 mph, which puts this Accord in the company of sports sedans."[335]
- Lexus LC500. "In most driving conditions, the [10-speed] transmission is an excellent match for the engine, adding to the fun by holding gears and downshifting smartly."[336]

2. *Variable valve and direct injection technologies*

Variable valve timing (VVT), variable valve lift (VVL), and gasoline direct injection (GDI) technologies increase engine power in addition to improving efficiency. VVT and VVL optimize valve timing to avoid compromises between efficiency and power, allowing more air to enter the engine when more power is needed. Because GDI injects fuel directly into the cylinder, evaporation of the fuel in the cylinder has a cooling effect, allowing more air and fuel to be burned without detonation.

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[332] https://www.caranddriver.com/reviews/2017-ford-f-150-35l-v-6-ecoboost-10-speed-first-drive-review
[333] http://www.motortrend.com/cars/ford/mustang/2018/2018-ford-mustang-ecoboost-first-test-chip-shoulder/
[334] https://www.roadandtrack.com/new-cars/car-technology/videos/a33243/the-10-speed-chevy-camaro-zl1-shifts-into-eighth-gear-at-180-mph/
[335] https://www.caranddriver.com/reviews/2018-honda-accord-in-depth-model-review-2018-honda-accord-fuel-economy-review-car-and-driver-page-3
[336] https://www.edmunds.com/lexus/lc-500/2018/review/

3. *Turbocharging*

Downsized, turbocharged engines are usually sized to maintain constant power at high engine speed. However, turbocharged engines can deliver their maximum power at lower engine speeds than naturally aspirated engines and have more torque at lower engine speeds. This means that turbocharged engines have better drivability, as the driver does not have to wait for the transmission to downshift to accelerate and provides an effortless acceleration feel, which is highly desired by many customers. They also climb steeper hills without having to downshift the transmission, and provide more towing ability. Magazine reviews include the following—

- BMW Mini. "It also is a major improvement over its 4-cyl. predecessor, the very competent 1.6L Prince engine, which BMW jointly developed with PSA Peugeot Citroen. The entry-level Mini's torque increases by 42%, and 0-60 mph acceleration is chopped by 2.3 seconds compared with the Prince. Fuel efficiency increases as much as 8%."[337]
- Jeep Wrangler. "Although the turbo 2.0-liter's 270-hp output is lower than the base V6's engine's, the 4-cylinder feels faster. Its twin-scroll turbocharger spools quickly, summoning 295 lb.-ft. of peak torque earlier in the rev range than the V6 does, making for good response."[338]
- Ford F150. "The other EcoBoost engine is a turbocharged 3.5-liter V6 that puts out 375 horsepower and 470 pound-feet of torque. That torque rating is higher than anything rivals offer, and it's a major reason why this engine is the best one for towing." "All of the F-150's engines are strong, but the turbocharged engines are the best towing options. They can tow heavy trailers without feeling the least bit strained, even when going uphill."[339]
- Ford F150. "We really liked the F-150's previous combination of the 3.5-liter EcoBoost and the six-speed automatic. The powertrain provides plenty of thrust and is nicely polished, which was enough for us to give it a win in a recent two-truck comparison test with the V-8–powered F-150."[340]
- Ford Mustang. "Regardless of which mode you prefer or how you dial in the settings, there's no denying the EcoBoost Mustang is damn quick on a back road once you figure out how to drive it right. This was born out at the test track, as well. At 5.3 seconds to 60 mph and 13.9 seconds in the quarter at 97.2 mph, this is the quickest EcoBoost Mustang we've ever tested."[341]
- Honda Accord. "The Accord has nixed its old V-6 and naturally aspirated four-cylinder engines in favor of a pair of downsized turbo fours, and the results are generally positive. Both new engines returned strong results in our testing, with the 2.0T model matching the impressive efforts of the outgoing V-6. The Accord's entry-level turbocharged 1.5-liter engine trounces the EPA figures of the previous 2.4-liter four-cylinder that it replaces. The

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[337] *http://wardsauto.com/2015/2015-winner-mini-15l-turbocharged-dohc-3-cyl*
[338] *http://www.nydailynews.com/autos/latest-reviews/drive-redesigned-2018-jeep-wrangler-review-article-1.3694649*
[339] *https://cars.usnews.com/cars-trucks/ford/f-150/performance*
[340] https://www.caranddriver.com/reviews/2017-ford-f-150-35l-v-6-ecoboost-10-speed-first-drive-review
[341] *http://www.motortrend.com/cars/ford/mustang/2018/2018-ford-mustang-ecoboost-first-test-chip-shoulder/*

2.0-liter turbo nets very modest fuel-economy gains compared to the V-6 it replaces, and the EPA's ratings were borne out in our real-world testing."[342]

Consumer demand for turbocharged engines is dramatically illustrated by the Ford 3.5L EcoBoost engine offered on their F150 pickup truck. The 3.5L V6 turbocharged engine was an optional engine on the F150. In the first model year, Ford charged an extra $1750 over the standard 3.7L V6 engine, or $595 over the 5.0L V8 standard in higher trim levels. Ford originally expected that 20% of customers would pay the additional $595 for the smaller engine.[343] The reality was that 45% of F150 customers paid $595 for the 3.5L EcoBoost and sales were higher than the standard 5.0L V8 (the F150 offered two other engines that combined for about 15% of sales, with 40% for the 5.0L V8).[344] Certainly the better efficiency of the smaller engine was desirable, but customers also wanted the higher low rpm torque and greater towing capacity of the 3.5L EcoBoost. These drivability and performance benefits make consumers more accepting of downsized-boosted engines, avoiding any tradeoffs that might make consumers balk at the technology.

4. Lightweighting

Lightweighting has many benefits beyond fuel savings that have substantial value to customers. These benefits include faster acceleration and better ride, handling, and braking, as well as higher towing and payload capacity. Aluminum also will not rust. Magazine reviews include:

- BMW 7-series. "The 2016 BMW 7 Series is a better dancer than the S-Class largely because it's lighter on its feet. Much of the new unibody, including the center tunnel, is made of carbon fiber — a payoff of BMW's huge investment in the stuff for Project i. That helps melt away up to 190 pounds compared with the last 7 Series and represents a 100-pound advantage over a similarly equipped S-Class. The 7 Series is thus quicker than before, even though its engines — a revised 4.4-liter turbo V-8 and an all-new 3.0-liter turbo inline-six — make similar power to their counterparts in the outgoing car."[345]
- Chrysler Pacifica. "This is Chrysler's sixth generation of the superlative kid hauler, which has never been quicker, better-looking, or more fuel efficient, and we promptly awarded it Best Van on our 10Best Trucks and SUVs list. Impressively, the new van managed to shed some weight in its redesign while getting substantially stiffer and acing NHTSA and IIHS crash tests."[346]
- Cadillac CTS. "Since its launch in 2003, the CTS sedan has been Cadillac's stylish, fun, and agile sports sedan. This model shed a couple of hundred pounds, grew four inches longer, and acquired a plusher, more posh interior. In short, it emerged from GM's

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[342] *https://www.caranddriver.com/reviews/2018-honda-accord-in-depth-model-review-2018-honda-accord-fuel-economy-review-car-and-driver-page-3*

[343] Aaron Isenstadt, John German, Mihai Dorobantu, David Boggs, Tom Watson, October 2016, Downsized, boosted gasoline engines. https://www.theicct.org/publications/downsized-boosted-gasoline-engines

[344] *Ibid.*

[345] *http://www.automobilemag.com/news/2016-bmw-7-series-review/*

[346] https://www.caranddriver.com/reviews/2017-chrysler-pacifica-long-term-test-review

finishing school as one of the most driver-focused midsized luxury sedans you can buy. The CTS delivers an inviting blend of comfort, quietness, and sporty driving performance."[347]

- Chevrolet Cruze. "The new Cruze benefits from a weight-reduction program that reduced weight up to 250 pounds from the previous car, despite the fact that the new car's wheelbase is 0.6-inch longer. The Cruze's light weight and stiff chassis contribute to smooth, composed handling."[348]

The additional value of lightweighting is supported by the 2015 fuel economy technology report published by the National Academy of Sciences (NAS),[349] which projected that manufacturers will reduce light-truck mass by 20% in 2025, despite high cost. They reached this determination because "implementation of mass reduction techniques can provide several benefits that might be attractive to an OEM."

As a specific example, the Ford Motor Company website for the F-150 pickup truck emphasizes the multiple benefits of lightweighting, not just fuel economy, "Doing something the right way often results in multiple benefits. Case in point: going from steel to high-strength, military-grade, aluminum alloys in the F-150 cab and bed. Hardening aluminum alloy through heat-treating produces greater strength. Working with aluminum alloy also allows engineers to increase gauge (or thickness) where needed to achieve extra strength without increasing weight. The stronger F-150 weighs up to 700 lbs. less than the previous generation, resulting in greater power-to-weight ratio, enhanced fuel efficiency, plus higher maximum payload and tow ratings that are best in class. Yet another benefit — resistance to dents and corrosion." [350]

5. 48-volt mild hybrids

The higher-voltage, higher-power electrical system on hybrids could offer many potential consumer features desired by customers; such as part-time 4wd, off-board power, heated seats, wiperless windshield systems, ride control systems, steer-by-wire, four-wheel steering, voice-activated controls, voice-recognition security systems, video systems, cellular phones, navigation systems, audio amplifiers, high-speed Internet access, stability control, short-range radar and video-camera warning systems, visibility systems for older drivers, and systems to detect and wake drowsy drivers. Other benefits result from the electric motor's ability to reduce turbo lag and improve drivability of turbocharged engines (see the E-boost discussion in Section II.A.)

While the use of higher electrical power to provide consumer features is somewhat hard to predict, a concrete benefit is that the electric motor can instantly deliver all of its power at low motor speeds, increasing lower engine speed torque. The drivability and performance benefits are similar to those of turbocharging, except that the low speed torque is available instantly and,

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[347] *https://www.consumerreports.org/cars/cadillac/cts/2015/overview*

[348] https://www.freep.com/story/money/cars/mark-phelan/2016/04/21/first-drive-2016-chevrolet-cruze-premier-compact-car/83321892/

[349] *National Research Council, Cost, Effectiveness, and Deployment of Fuel Economy Technologies for Light-Duty Vehicles (Washington, DC: National Academies Press), 2015. doi:10.17226/21744. (see pp. 6–10, specifically).*

[350] *https://www.ford.com/trucks/f150/features/Tough/?intcmp=vhp-featcta-tough, accessed October 5, 2018.*

thus, is even better than turbocharging where the torque boost is delayed by turbo lag. Magazine reviews include:

- Dodge RAM pickup truck. "The total eTorque system, cables and all, adds about 100 pounds of weight to the truck. What you get in return for the weight penalty is a 90 lb-ft of torque boost with the V6 and a full 130 lb-ft worth of help with the V8." "The 2019 Ram comes either with a 3.6-liter V6 outputting 305 hp and 269 lb-ft of torque or a 5.7-liter V8 with 395 hp and 410 lb-ft. And those peak numbers are unaffected by the eTorque system. The extra oomph comes in when the gas engines are at low speed, like between idle and 1,500 rpm, before they are able to produce bigger torque numbers on their own. The hybrid system *broadens the torque band* as opposed to *adding to peak torque available*." "And that's just fine. Peak torque is useless when you're trying to pull your 22-foot deck boat out of the water at 0-2 mph. Adding torque down low not only helps get heavy loads moving from a standstill, it takes stress off the powertrain while doing so."[351]
- Jeep Wrangler. "It is paired with an 8-speed automatic and features a new eTorque mild-hybrid system with a belt-driven 48-volt starter/generator and regenerative braking. The idea here is to inject electrically fed torque immediately following accelerator application to reduce lag, and to improve efficiency when coasting and by shutting the engine off sooner as the Wrangler comes to a stop." "Considering that a 4,000-lb Alfa Romeo Stelvio can sprint from zero to 60 mph in around 5.5 seconds, the slightly heavier Wrangler 4-door should be able to manage the same feat in about six seconds. And that's not factoring in the electric power assist from the eTorque system, which you can definitely feel in the seat of your pants." "But considering that the eTorque hybrid system supplies fuel shut-off during coasting and deceleration, intelligent battery charging, and regenerative braking, it should have no trouble improving upon the V6 engine's ratings of 18-city/23-highway."[352]

As discussed in Section II.B. and the magazine review, the eTorque system on the 2019 RAM 1500 pickup truck improves performance and drivability and contributes to higher payload and towing ratings for the 2019 pickup truck. In fact, the very branding of the option as eTorque suggests that RAM believes the utility benefits are more important to customers than the fuels savings.

In summary, it is clear from the discussion in this section, that many efficiency technologies offer other benefits that are highly valued by consumers. In particular, the consumer benefits of turbocharging, lightweighting, and 48v hybrids are likely just as large as the value consumers place on the fuel savings. Yet the agencies modeling both assumes that automakers will deploy some of the technology for performance benefits rather than fuel economy (contrary to the agencies' statements that they only model performance parity), and assigns 100% of the costs to the fuel economy and GHG standards. This is not appropriate and dramatically understates the benefits of efficiency technology and overstates the cost to reduce fuel consumption and CO_2.

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[351] http://autoweek.com/article/technology/2019-ram-etorque-system-torque-down-low#ixzz5EMQzduXx

[352] http://www.nydailynews.com/autos/latest-reviews/drive-redesigned-2018-jeep-wrangler-review-article-1.3694649

D. Overall cost-benefit analysis

Given the short time for comment, we have assessed many of the major decisions that the agencies have proposed. Overall, as discussed above, the agencies have made many dozens of decisions regarding their data and methods to override their previously adopted GHG and Augural CAFE 2025 standards. The agencies have transformed a robust and overwhelmingly beneficial regulation into a regulation that, on paper, artificially looks poor based on faulty, poorly supported, and less-rigorous assumptions that it has buried in their opaque and hard-coded modeling algorithms.

Because the agencies chose not to provide a clear summary of the changes from their previous analysis, we present into the record a summary of how the agencies have transformed the rulemaking's overall cost-benefit analysis, so it is more plainly visible exactly what costs it chose to prop up, and what benefits it chose to diminish. This section summarizes early findings on several aspects related to the cost-benefit analysis and the technology assessment within the August 2018 regulatory analysis on proposed U.S. light-duty vehicle standards. The following three parts illustrate the overall regulatory program costs and benefits, the per-vehicle costs and benefits, and the percent change in costs and benefits from three cases: (1) EPA original Proposed Determination in 2016 and Final Determination in 2017, (2) Joint-agency EPA-NHTSA-California Draft TAR from 2016, and (3) the EPA-NHTSA NPRM from 2018.

1. Program costs and benefits

Table 13 summarizes the past three regulatory assessments of the U.S. light-duty vehicle regulations for fuel economy and greenhouse gas emissions. The table summarizes the overall societal benefits and costs of the current standards from three analyses: (1) EPA's analysis in its Final Determination on the appropriateness of the 2025 standards in January 2017[353]; (2) NHTSA's analysis in the joint-agency Technical Assessment Report in July 2016[354]; and (3) NHTSA's latest analysis in the NPRM in August 2018[355]. Along with the societal impacts for the technology cost and other impacts in billions of dollars, the final rows include overall effect on the vehicle model years affected, number of vehicles in the analysis, and resulting benefit-to-cost ratio. The figure shows the various areas where there were problematic assumptions (as identified above) that falsely led to a negative 2018 benefit-to-cost analysis (i.e., with lower benefit than cost), from what had been a robust finding of a regulation with benefits 2-3 times the costs.

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[353] *EPA, "Proposed determination on the appropriateness of the model year 2022–2025 light-duty vehicle greenhouse gas emissions standards under the midterm evaluation" (2016). https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100Q3DO.pdf. EPA, "Final determination on the appropriateness of the model year 2022–2025 light-duty vehicle greenhouse gas emissions standards under the midterm evaluation" (2017). https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100QQ91.pdf*

[354] *EPA, NHTSA, and California Air Resources Board, "Draft technical assessment report: Midterm evaluation of light-duty vehicle greenhouse gas emission standards and corporate average fuel economy standards for model years 2022-2025" (July 2016). https://nepis.epa.gov/Exe/ZyPDF.cgi/P100OXEO.PDF?Dockey=P100OXEO.PDF*

[355] *EPA, NHTSA, "The safer affordable fuel-efficient vehicles rule for model years 2021-2026 passenger cars and light trucks; Notice of proposed rulemaking" (August 2018). https://www.nhtsa.gov/corporate-average-fuel-economy/safe*

Table 13. Impact of U.S. efficiency and GHG regulations.

	FACTOR	EPA FINAL DETERMINATION (JANUARY 2017)		NHTSA TECHNICAL ASSESSMENT REPORT (JULY 2016)		NHTSA PROPOSED REGULATION (AUGUST 2018)	
		Costs	Benefit	Cost	Benefit	Cost	Benefit
Societal impact ($ billion)	Technology cost	-$34		-$68		-$253	
	Fatalities and crashes	-$8		-$5		-$198	
	Congestion noise	-$1		-$1		-$52	
	Fuel savings		$92		$122		$133
	Pollution benefit		$28		$38		$6
	Other impacts		$19		$15		$126
	Additional travel		$2		$9		$61
Overall effect	Model years affected	2022-2025		2022-2028		2020-2029	
	Total number of vehicles	65 million		115 million		165 million	
	Benefit-cost ratio	3.3-to-1		2.0-to-1		0.6-to-1	

2. *Per-vehicle program costs and benefits*

Figure 10 shows the impacts from Table 13, normalizing them to a *per-vehicle basis* for all the vehicles included in each regulatory assessment to help isolate the major differences in the cost-benefit analyses. Moving from left to right shows the EPA Final Determination analysis, the NHTSA TAR analysis, and NHTSA's latest proposal analysis for the current standards. As shown, the EPA Final Determination analysis indicates $660 in total average per vehicle cost and $2160 in benefits. The three largest factors in EPA's analysis are the technology cost (-$523 per vehicle), fuel savings ($1,415), and pollution benefit ($431), and the overall benefit-cost ratio is 3.3-to-1. The latest pre-proposal analysis by NHTSA from 2016 shows a relatively similar analysis but higher costs and lower benefits resulted in a 2.0-to-1 benefit cost ratio. Compared to EPA's analysis the primary difference is that it used costs that were 40% higher ($1,425 for NHTSA versus $875 for EPA for model year 2025 vehicles). The latest NHTSA analysis to justify a freeze in post-2020 standards shows a 0.6-to-1 benefit cost ratio for the current standards. Overall, including model year 2021-2029 vehicles, the 2018 NPRM indicates total societal costs of $3,100 per vehicle compared to societal benefits of $2,000. The differences from EPA and NHTSA's previous analysis, including in technology cost, fuel saving benefits, and the fleet-level impacts are vast, and explored in detail in the analysis above.

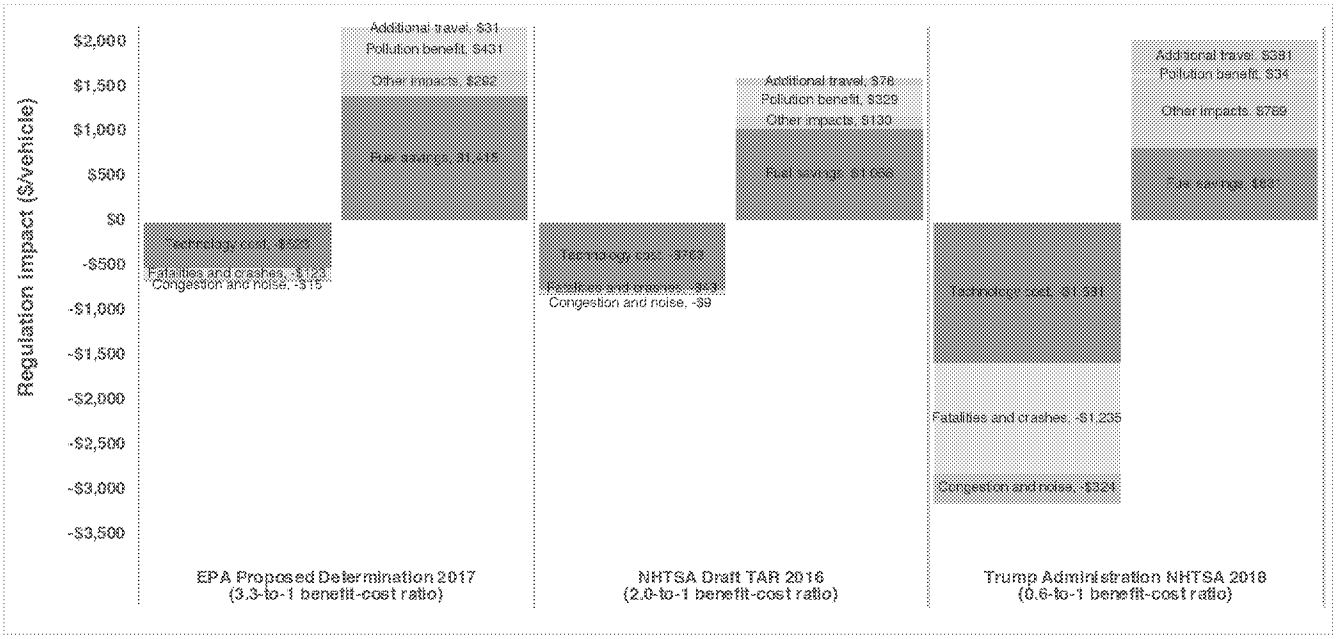

Figure 10. Per-vehicle impact from vehicle efficiency and GHG standard analyses.

3. Changes in per-vehicle costs and benefits from previous

Table 14 summarizes how the impacts have changed from the previous analyses to the latest 2018 NHTSA proposal. By comparing the cost elements of the August 2018 proposal regulatory analysis from Figure 10 with the associated impacts in the previous two analyses, we see how the latest regulatory assessment resulted in such a different outcome. The NHTSA 2018 proposal analysis of the Augural standards shows greatly increased technology costs (by 2-3 times), fatalities and crash costs (by 10-28 times), congestion and noise costs (by 21 to 37 times)—while also showing decreased fuel-saving benefits (by 21%-41%) and pollution benefits (by 90%-92%).

We provide these differences to underscore just how dramatically the agencies have changed their results since their previous technical assessment. Examining the assumptions as we have done above, we find that if the agencies restored key data technology inputs on effectiveness and cost, technology modeling assumptions, and cost-benefit modeling assumptions (such as the rebound, sales, scrappage, and other technology input errors and inconsistencies discussed above), their overall benefit-cost ratio would flip right back to at least a 2-to-1 ratio, as it was previously. However, we point out that the agencies have not systematically done any such comparison that breaks down how, where, and why they have made all these changes. The above comments help to at least partially illustrate and summarize the ways that the agencies have artificially flipped their regulatory impacts results.

Table 14. Impact of U.S. efficiency and GHG regulations.

	IMPACT PER VEHICLE ($/VEHICLE)			CHANGE FROM 2016-2017 TO 2018 ANALYSIS	RATIONALE FOR CHANGES, AS BEST WE HAVE DETERMINED FROM NPRM
	EPA 2017	NHTSA 2016	NHTSA 2018		
Technology cost	-$523	-$763	-$1,581	107% to 202%	• Technology availability is limited • Technologies have less benefits • Technology costs are greater • Technology applicability is restricted • Manufacturer-specific constraints limit technology • Technology pathways limit technology options • Technology pathways limit technology combinations • Air-conditioning technology removed
Fatalities and crashes	-$123	-$43	-$1,235	904% to 2750%	• Rebound: More driving as drivers capitalize on fuel savings leads to more crashes (20% vs 10% previously) • Sales: More new vehicle technology means lower sales (by about 857,000) and more older vehicle use
Congestion and noise	-$15	-$9	-$324	2009% to 3642%	• More driving as drivers capitalize on fuel savings means more congestion
Fuel savings	$1,415	$1,058	$831	-21% to -41%	• In absence of new 2020+ standards, efficiency increases from 36 in 2020 to 38.4 mpg in 2026 (previously, a flat baseline in absence of standards was assumed)
Pollution benefit	$431	$329	$34	-90% to -92%	• New analysis finds that CO2 damages are (approximately $9/ton versus $41/ton previously)
Other impacts	$292	$130	$789	170% to 507%	• This is an offsetting benefit as a result of drivers freely choosing to drive more
Additional travel	$31	$78	$381	389% to 1140%	• More driving as drivers capitalize on fuel savings

Source: US EPA and NHTSA regulatory assessments.

III. Regulatory certainty and jobs

Although there is overwhelming evidence to support the development of even more stringent standards than the existing GHG and augural fuel economy standards, in the interest of maintaining nearer term regulatory certainty for industry investments, we believe that maintaining EPA's adopted GHG standards and NHTSA's CAFE standards for model years 2021-2025 is appropriate. Maintaining 2022-2025 regulatory stringency would assure a stable regulatory environment and is well supported by the evidence.

Any new uncertainty about the federal 2025 standards would provoke uncertainty with California and other states (representing as much as one third of the U.S. market), who will continue to develop policies to enforce the equivalent of the existing standards on all passenger cars and light trucks sold within their borders. It is not just Section 177 states and California that stand opposed to the agencies proposal. Based on the positions as of August 14, 2018, state and city commitments to cleaner cars represent over half – 55% – of the U.S. auto market.[356] The opposition from states and cities is due to their obligations to provide clean air for their resident populations and mitigate the worst consequences of climate change.

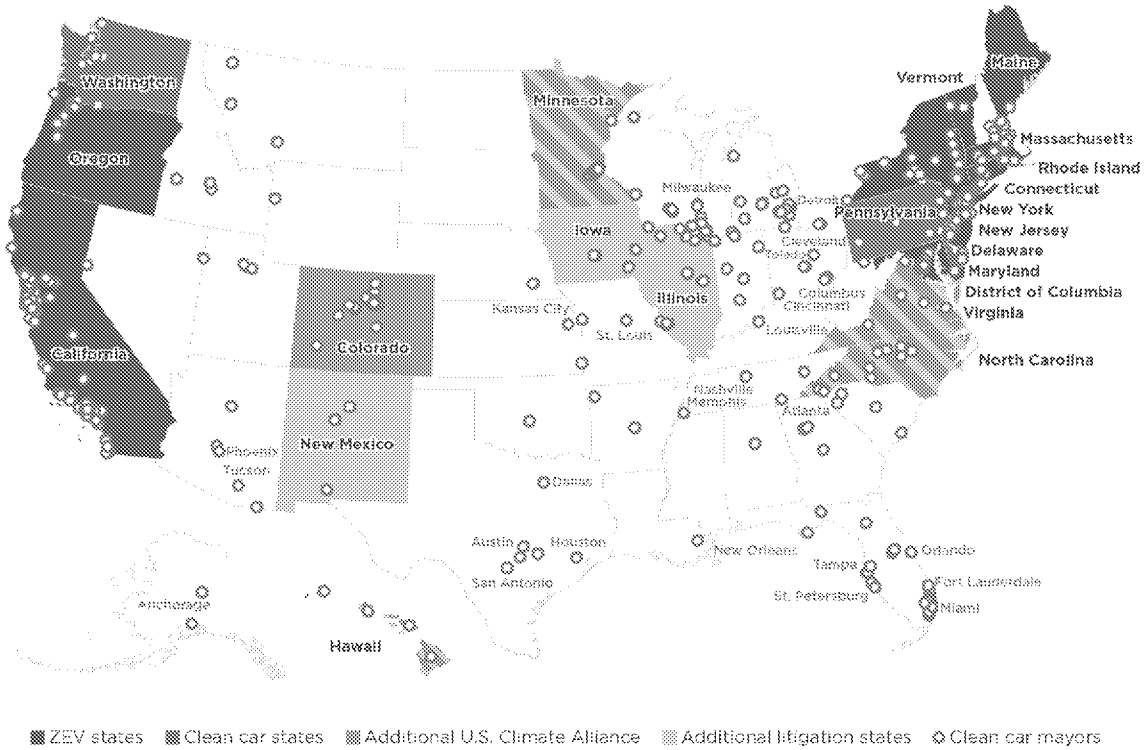

Figure 11. States and cities opposing the proposed rollback of federal CAFE and GHG regulations.

[356] *Lutsey, N. and P. Slowik (2018). States and cities seeking to maintain clean car standards. https://www.theicct.org/publications/state-city-clean-car-20180814*

These jurisdictions' continued opposition to the weakening of the federal CAFE and GHG standards virtually ensures the proposed rollback to the vehicle standards will be tied up in courts for years. This will also cause great uncertainty for automakers, which face the prospect of either planning to comply with the existing adopted 2025 GHG rules or halting progress towards cleaner and more efficient cars. If the rollback moves forward, the states and cities will be much farther behind in their ability to meet their air quality and climate goals, many of which are legal requirements. It seems clear that the opposing states and cities are going to impose a wide array of city- and state-level policies that will be more complicated for the auto industry to grapple with in the years ahead, if the federal policy is weakened and state government authority is removed.

Destabilization of the 2025 standards would put grave uncertainty on the returns on major investments that automakers and suppliers have made. Table 15 highlights a selection of industry investments in the U.S. related to automobile efficiency technology[357]. As shown, the investments represent many thousands of high-tech manufacturing jobs and billions of dollars in investments. The success and sustainability of such technology investments depends on a stable regulatory environment. There is a clear connection between the standards and investments that directly contribute to American jobs. In fact, the agencies' own modeling in the NPRM did indeed model how the proposed rollback would result in a loss of 50,000 jobs per year by 2021 and 60,000 jobs per year by 2023.[358] Maintaining the standards would protect high-technology manufacturing investments in efficiency technologies, whereas weakening or uncertainty about the standards jeopardizes such investments. In addition, any new uncertainty about the federal 2025 standards would cause uncertainty with California and other states and their continuation with adopted 2025 regulatory standards.

ICCT supports EPA's 2016 critique in the Proposed Determination of the jobs study by the Center for Automotive Research (CAR).[359] ICCT also wrote a detailed critique[360], discussing the multiple problems with this study. In short, the report rests on a false premise about the costs of meeting the standards. CAR ignored the dozens of recent state-of-the-art technology analyses and, instead, the report relies on costs from a twenty-five-year-old retail-price manipulation strategy. A 1991 study by David Greene[361] found that automakers could improve their CAFE fuel economy level by increasing the sales price of less fuel efficient models while simultaneously decreasing the price of more fuel efficient models. Greene concluded that this pricing scheme is effective in the short-run for fuel economy improvements of *up to* 1 mpg, and would cost $100–$200 (in 1985 dollars). But, Greene also found, for fuel economy improvements greater than 1 mpg, pricing out less-efficient vehicles generates increasing losses for automakers and

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[357] *Lutsey, N. (2012). Regulatory and technology lead-time: The case of US automobile greenhouse gas emission standards. Transport Policy. 21: 179-190. http://www.sciencedirect.com/science/article/pii/S0967070X12000522*

[358] *83 Fed Reg at 43265*

[359] *https://www.cargroup.org/publication/the-potential-effects-of-the-2017-2025-epanhtsa-ghgfuel-economy-mandates-on-the-u-s-economy/*

[360] *Isenstadt, A. (2016). The latest paper by the Center for Automotive Research is not what it thinks it is. http://www.theicct.org/blogs/staff/latest-paper-by-CAR-is-not-what-it-thinks-it-is*

[361] *Greene, D.L., (1991). Short-run pricing strategies to increase corporate average fuel economy http://onlinelibrary.wiley.com/wol1/doi/10.1111/j.1465-7295.1991.tb01256.x/abstract*

improved technology and design changes are by far the more cost-effective solution for long-term, large fuel economy improvements. CAR ignored Greene's findings on mpg changes of more than 1 mpg and applied the retail-price manipulation results to the 2025 standards. Further, CAR ignored the economy-wide jobs created by reduced spending on fuel after the first 3 years of ownership.

Table 15. Auto industry investment and job growth related to efficiency technologies

Company	Technology	Location	Jobs	Investment
Ford	Efficient engines (EcoBoost)	Cleveland, Ohio	250	$55 million
GM	Efficient engines (Ecotec)	Tonawanda, New York	350	$825 million
GM	Efficient engines (Ecotec)	Spring Hill, Tennessee	483	$483 million
GM	Engine, transm., stamping	Lordstown, Ohio	1200	$500 million
Hyundai	Efficient engines	Montgomery, Alabama	522	$270 million
Chrysler	Engine (FIRE)	Dundee, Michigan	150	$179 million
ZF	Transmissions	Laurens County, South Carolina	900	$350 million
Toyota	Transmission, aluminum parts	Buffalo, West Virginia; Jackson, Tenn.; Troy, Missouri	40	$64 million
GM	Transmission, electric motors	White Marsh, Maryland	200	$246 million
Fiat-Chrysler, ZF	Transmission (8-speed)	Kokomo, Indiana		$300 million
Bosch	Gasoline injectors, diesels	Charleston, South Carolina	300	$125 million
Michelin	Tires	South Carolina	100	$350 million
Lenawee Stamping	Metal stamping	Tecumseh, Michigan	140	
Tenneco Autom.	Emission control	Michigan	185	$15.6 million
Gestamp	Stamping	Chattanooga, Tennessee	230	$90 million
Gestamp	Steel components	Mason, Michigan	348	$74 million
ThyssenKrupp	Steel	Mount Vernon, Alabama	2700	$3700 million
Nanshan	Aluminum extrusion parts	Lafayette, Indiana	200	$100 million
Magna	Composite parts	North Carolina	327	$10 million
BMW, SGL	Carbon fiber parts	Moses Lake, Washington	80	$100 million
Faurecia, Ford	Plastic parts	US and Mexico	350	
TRW, Ford	Electric power steering	Marion, Virg; Rogersville, Tenn.	115	$55 million
Continental, Ford	Engine, brakes, tires, access.	Henderson, North Carolina	60	
Nexteer Autom.	Driveline, steering	Saginaw, Michigan		$431 million
Denso	Aluminum parts	Hopkinsville, Kentucky	80	$4.2 million
NHK	Suspension parts	Bowling Green, Kentucky	100	$20 million
Ford	Fuel-efficient, hybrid, electric vehicles	Louisville, Kentucky	1800 (7000)	$600 million ($1000 million)
V-Vehicle	Hybrid vehicles	Monroe, Louisiana	1400	$248 million
GM	Battery, drivetrain, engine, generator	Brownstown, Hamtramck, Warren, Bay City, Grand Blanc, and Flint, Michigan	1000+	$700 million
Nissan	Electric vehicles, components	Smyrna, Tennessee	1300	$1700 million
Magna	Electric drive components	Michigan	500	$49 million
Ford	Batteries, transaxles	Rawsonville, Sterling Heights, Michigan	170	$135 million
Toda America	Batteries	Battle Creek, Michigan	60	$35 million
JC-Saft	Batteries	Holland, Michigan	550	$299 million
LG Chem	Batteries	Holland, Michigan	400	$151 million
Fortu PowerCell	Batteries	Muskegon Township, Michigan	1971	$625 million
Bannon Autom.	Electric vehicles	Onondaga County, New York	250	$26.6 million
A123	Batteries	Ann Arbor	5000	$600 million
Magna	Batteries, drivetrain, power electronics, flexible foam	Auburn Hills, Troy, Shelby Township, Lansing, Michigan	500	$50 million
Toyota, Tesla	Electric vehicles	Fremont, California	1000	$50 million

Source: Lutsey, N. (2012). Regulatory and technology lead-time: The case of US automobile greenhouse gas emission standards. Transport Policy, 21: 179-190. http://www.sciencedirect.com/science/article/pii/S0967070X12000522

Fuel savings from fuel economy and GHG regulations contribute to increased employment. There are three ways that fuel economy standards can potentially impact jobs:

1. Vehicle price effects, through a potential decline in new vehicle sales and higher vehicle prices for consumers, which in turn curbs spending on other goods and services
2. Supply chain innovations induced by the regulations
3. Savings in gasoline expenditures, which give consumers move money to spend on other goods.

However, the NPRM only analyzed the first two of these three factors. For the first two factors, the NPRM modeled a loss of 50,000 jobs by 2021 and a loss of 60,000 jobs by 2023 for the proposed rule to roll back the standards.[362] However, economy-wide job gains from the fuel savings of the 2012 rule were completely ignored. While these jobs do not directly affect the auto sector, the failure to assess economy-wide job gains from fuel savings is a clear bias in the NPRM.

Fuel savings are extremely important because spending a dollar on fuel creates far fewer jobs than spending a dollar on general goods or services in the U.S. economy. Modeling done by Indiana University in 2017,[363] with corrections in 2018,[364] found that when properly accounting for all three impacts, the augural standards create more than 300,000 jobs by 2035. This is a major study originally contracted by the Alliance of Automobile Manufacturers that was submitted to the docket. Yet the agencies failed to even mention this study or, indeed, include any discussion of job impacts from reduced fuel expenditures.

For an administration that claims to be all about jobs, and that is rolling back emission standards and damaging public health in the name of creating jobs, it is inexplicable why the agencies would want to destroy over 300,000 jobs by rolling back the efficiency standards.

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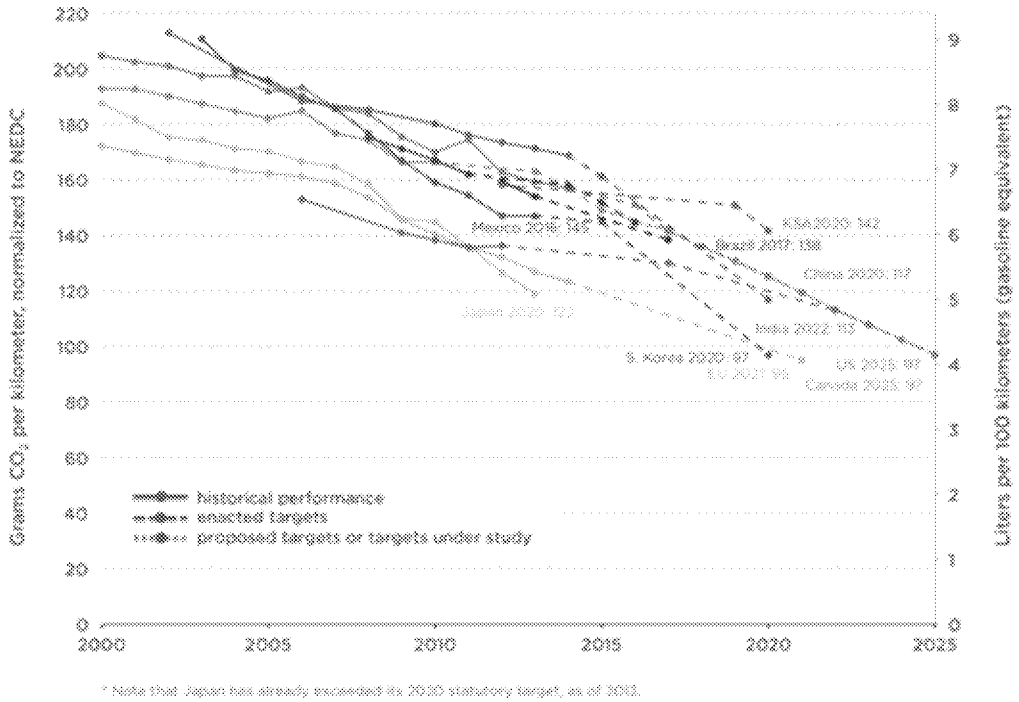
[362] *83 Fed Reg at 43265*

[363] *Sanya Carley, Denvil Duncan, John D. Graham, Saba Siddiki, and Nikolaos Zirogiannis, A Macroeconomic Study of Federal and State Automotive Regulations with Recommendations for Analysts, Regulators, and Legislators", School of Public and Environmental Affairs Indiana University, March 2017. https://spea.indiana.edu/doc/research/working-groups/auto-report-032017.pdf*

[364] *COMET corrected, SPEA, February 2018. https://spea.indiana.edu/doc/research/working-groups/comet-022018.pdf*

IV. International competitiveness

The currently adopted U.S. GHG regulations and augural CAFE standards have the U.S. fleet headed in the same direction as most other major world automobile markets, reducing per-mile carbon dioxide (CO_2) emissions at approximately 3% per year. About 80% of world automobile sales are regulated to increase their efficiency and reduce carbon emissions.[365] Like the U.S. standards, all other standards around the world are indexed to vehicle size (or mass), and therefore require that efficiency technologies like those described above are increasingly deployed on all vehicles in the fleet. Figure 12 shows the progression of global efficiency standards in major world car markets.[366] In the U.S. case, industry consistently met the 2012-2015 standards while U.S. vehicle sales increased to an all-time high, and with most companies producing high profits.



* Note that Japan has already exceeded its 2020 statutory target, as of 2013.

Figure 12. Passenger car efficiency standard CO_2 emissions (with U.S. standards as currently adopted)

If EPA, NHTSA, and California maintain the adopted 2025 standards, this would ensure that the U.S. auto market remains globally competitive with Europe, China, and elsewhere. However,

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[365] *International Council on Clean Transportation. Passenger vehicle fuel economy. https://www.theicct.org/chart-library-passenger-vehicle-fuel-economy*

[366] *International Council on Clean Transportation, 2015. Global passenger vehicle standards. http://www.theicct.org/info-tools/global-passenger-vehicle-standards*

the administration's proposal would do the opposite: as illustrated in Figure 13, rolling back the vehicle efficiency standards would put the United States out of step with the rest of the global major auto markets that are seeing continued innovation. In particular, the policies of China or Europe are increasingly driving global technology innovation and investment.

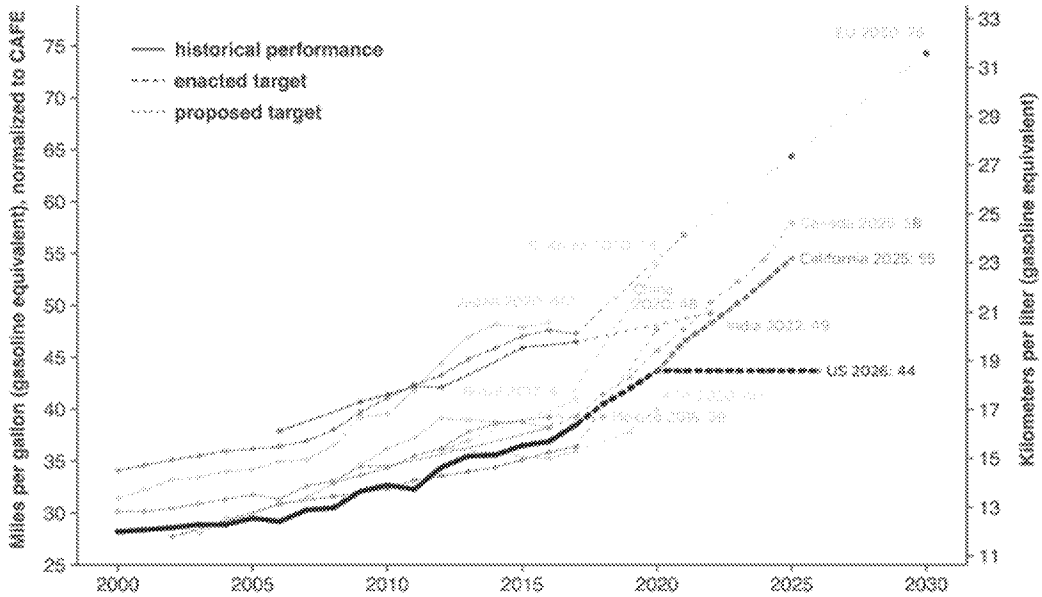

Figure 13. Comparison of international fuel economy, fuel consumption, and GHG emission standards, with proposed post-2020 freeze on U.S. standards shown[367]

Based on the agencies' own analysis, the lost technology investments from the rollback will be profound. The rollback means far lower annual technology deployment, including, for example many millions less turbochargers, direct injection engines, mild hybrid systems, and advanced 10-speed transmissions by 2026[368] (see Figure 3). The proposed freeze on standards at the 2020 levels ensures that products designed for the U.S. market will be less competitive globally, and that vehicles designed in Europe and Asia will have more technical innovation and technology investment on vehicle efficiency and electrification.

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[367] *International Council on Clean Transportation. The Trump Administration's vehicle efficiency proposal is not supported by underlying data and runs counter to global trends. https://www.theicct.org/news/us-cafe-proposal-pr-201808*

[368] *Forbes. By freezing vehicle standards, the Trump Administration will grind auto innovation to a halt. https://www.forbes.com/sites/danielsperling/2018/08/20/by-freezing-vehicle-standards-the-trump-administration-will-grind-auto-innovation-to-a-halt/#462b1968550e*

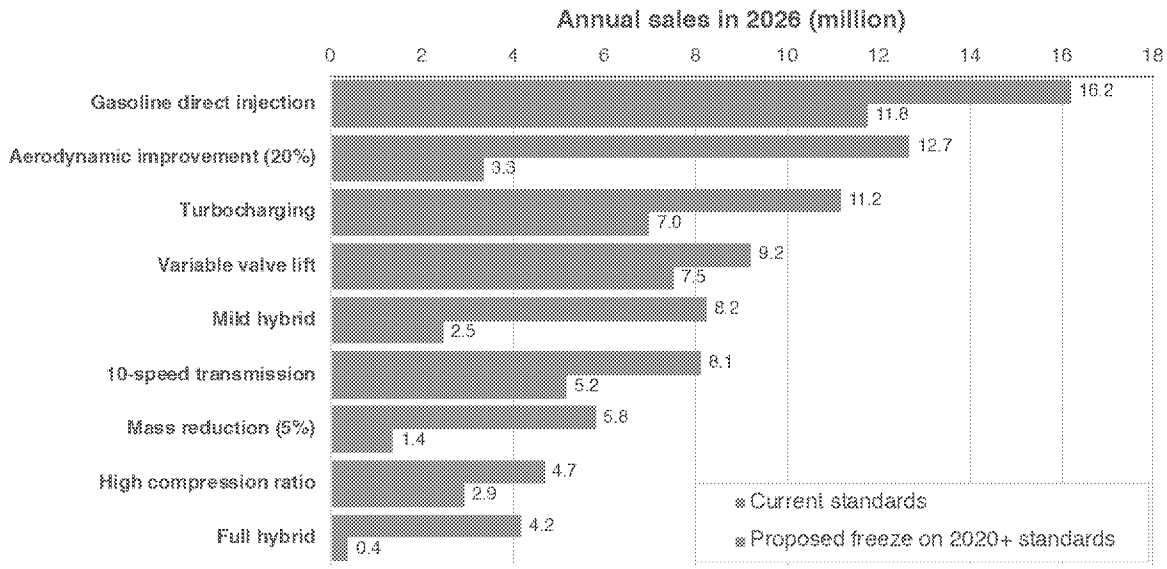

Figure 14. Annual sales of efficiency technologies in 2026 under currently planned standards and under a freeze of standards at 2020 levels (based on NHTSA estimates)[369]

The proposal would put us back into the cycle that occurred from the mid 1980s to early 2000s when frozen vehicle efficiency standards caused U.S. vehicle technology to stagnate, when domestic manufacturers became less competitive, contributing to General Motors and Chrysler declaring bankruptcy just nine years ago.

[369] *Forbes. By freezing vehicle standards, the Trump Administration will grind auto innovation to a halt. https://www.forbes.com/sites/danielsperling/2018/08/20/by-freezing-vehicle-standards-the-trump-administration-will-grind-auto-innovation-to-a-halt/#462b1968550e*

V. Zero-emission vehicles

The agencies sought comment on "the extent to which compliance with the ZEV mandate frustrates manufacturers' efforts to comply with CAFE standards."[370] The agencies' proposed approach to remove the authority of California and other states on low-emission vehicles is profoundly shortsighted. In 2018, the global auto market is at the early stages of a significant and unprecedented transition to an alternative fuel vehicle technology. This transition of course is toward zero-emission electric vehicles. Nearly every major automaker has, in some form or another, publicly indicated that they believe the future of the automotive industry is electric. These automakers include Audi,[371] BMW,[372] General Motors,[373] Mercedes Benz,[374] Mitsubishi,[375] Nissan,[376] Porsche,[377] Renault,[378] Škoda,[379] Tesla[380], Toyota,[381] Volkswagen,[382] and Volvo[383].

Many automakers have publicly shared details on their plans for an electric future, including targets and a timetable. The table below sums up the automakers' announcements for electric vehicles, reflecting only investments and intended sales of plug-in (and small amounts of fuel cell) vehicles – announcements for hybrids without plug-in capability are excluded. These total $200 billion in electric vehicle investments and over 15 million electric vehicle sales per year by 2025. Considering there were about 1.2 million global electric vehicle sales in 2017, this increase in electric vehicle sales, based on automakers' announcements, amounts to an order of magnitude increase in 8 years. These announcements signal the timing for the industry as a whole to cross the proverbial "valley of death" to where electric vehicles ultimately reach significant production volume and achieve economies of scale needed for profitability.

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[370] *The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021–2026 Passenger Cars and Light Trucks, 83 Fed. Reg. at 43239*
[371] *Jardine Motors. https://www.jardinemotors.co.uk/audi/news/future-electric-etron/*
[372] *BMW. https://www.bmw.com.au/world-of-bmw/bmw-news*
[373] Linkedin. https://www.linkedin.com/pulse/we-believe-all-electric-future-heres-what-were-doing-today-mary-barra/
[374] Mercedes Benz. https://www.mercedes-benz.com/en/mercedes-benz/next/e-mobility/the-future-is-electric/
[375] Wheels. http://wheels.ae/news/news-stories/article/3871/renault-nissan-and-mitsubishi-motors-alliance-the-future-is-electric
[376] Nissan. https://www.nissan.co.uk/experience-nissan/electric-vehicle-leadership.html
[377] Fortune. http://fortune.com/2015/03/26/porsche-electric-cars/
[378] *Car Magazine. https://www.carmagazine.co.uk/car-news/tech/ze-boss-eric-feunteun-on-renaults-electric-ev-future/*
[379] *Skoda. http://www.skoda.ie/news/news-detail/future-is-electric*
[380] *Tesla. https://www.tesla.com/blog/future-cars-electric*
[381] *Toyota. https://newsroom.toyota.co.jp/en/corporate/20353243.html*
[382] *Wall Street Journal. https://www.wsj.com/articles/vws-ceo-knows-the-future-is-electricfirst-he-must-convince-his-company-1501598237*
[383] *Volvo. https://www.volvocars.com/us/about/our-innovations/drive-e*

Table 16. Automaker electric vehicle announced investments and future year sales[384]

Automaker group	Announced investment	Global sales (shares)
Nissan-Renault-Mitsubishi	$9.5 billion	3 million (30%) by 2022
Volkswagen	$40 billion+$60 billion (battery)	2-3 million (20-25%) by 2025
Toyota	(not available)	2 million (25%) by 2025
Chonqing Changan	$15.9 billion	1.7 million (100%) by 2025
BAIC	$3.4 billion	1.3 million (100%) by 2025
Geely	$3.3 billion	1.1 million (90%) by 2020
General Motors	(not available)	1 million (12%) by 2026
Tesla	$4-5 billion	1 million (100%) by 2020
Mercedes	$13 billion	0.4-0.6 million (15-25%) by 2025
BMW	$2.4-3.6 billion	0.4-0.6 million (15-25%) by 2025
Ford	$11 billion	(not available)
Dongfeng	(not available)	0.4 million (30%) by 2022
Hyundai	$22 billion	(not available)
Fiat-Chrysler	$10.5 billion	(not available)
SAIC	$2.9 billion	(not available)
Great Wall	$2-8 billion	(not available)

We also note several other applicable global developments on the electric vehicles, based on our recent analysis.[385] Five regions of China, Europe, Japan, South Korea, and the United States account for nearly all global electric vehicle production to date (the U.S. is now third, after China and Europe). These markets have grown fastest because they have had clear policies that support the transition of the auto industry, while also supporting the consumer market. The successful policies in the top global markets include vehicle regulations, incentives, charging infrastructure, and consumer awareness campaigns. Due to the sustained policy support from those early markets, nearly every automaker has made significant strides to develop their electric vehicle supply chain. By 2017, there were six battery companies supplying batteries for at least 100,000 electric vehicles per year and 10 automakers making at least 50,000 electric vehicles per year. From global electric vehicles sales of just hundreds per year in 2010, these developments make it clear where the world is headed.

Along with being driven by policy developments, what we found in our global study is that electric vehicles are primarily manufactured in the region where they are sold. So, if the U.S. wants to be on the leading edge of the transition to electric vehicles—from an *industrial* perspective—it will need to support the growing U.S. electric market. However, the proposed rollback to the CAFE and GHG standards, and especially doing so while withdrawing state authority to protect their air and the climate, would do the opposite of this. The proposal would strike a blow, not just to U.S. environmental goals at all levels, but also to long-term U.S. automotive industry leadership in new electric-drive technologies. Even though nearly every

[384] *Lutsey, N, 2018. https://www.theicct.org/blog/staff/future-is-electric-but-why-so-long*

[385] *Nic Lutsey, Mikhail Grant, Sandra Wappelhorst, Huan Zhou. Power play: How governments are spurring the electric vehicle industry. May 15, 2018. https://www.theicct.org/publications/global-electric-vehicle-industry*

automobile company leader is affirming electric vehicles are their future, as indicated above, they are planning their investments in manufacturing plants where the market is, and increasingly that appears to be in China and in Europe.

These automotive developments, with leading electric vehicle makers moving toward economies of scale and staking out their positions in the evolving market, coincide with the timeframe of the proposed U.S. regulation. As indicated by the agencies' data, compliance with the 2025 augural CAFE and adopted GHG standards, even without the proposed freeze on post-2020 standards, would result in less than 3% of new vehicles being plug-in electric by model year 2025.[386] The agencies' proposal would virtually guarantee that the U.S., and its automotive manufacturing industry in particular, is not playing an integral role in the world's long-term transition to zero-emission mobility. With the agencies' proposal, U.S.-based auto companies would be increasingly vulnerable over the long-term as a global shift to electric vehicles passes it by.

Yet, the California-initiated Zero-Emission Vehicle regulation has kept the U.S. vehicle market apace with the global transition to electric vehicles. California alone amounts to half of U.S. electric vehicle sales with electric vehicle uptake that is over 5 times that of the rest of the U.S.[387] Including the nine other ZEV-adopting states, the ZEV regulation applied to 29% of the U.S. auto market and accounts for 63% of U.S. electric vehicle sales.[388]

The immense progress to date to grow the U.S. electric vehicle market was, in part, because the federal government, California, and the auto industry were willing to come together in 2011 to agree on stable long-term standards to 2025. It was also in large part due to the leadership of California and other states in utilizing their authority to implement their regulations and the supporting policy to help meet their longstanding clean air and climate commitments. We recommend the agencies do not revoke the California waiver and take no action toward removing state-level regulatory authority.

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[386] Outputs from NHTSA datafiles. National Highway Safety Traffic Administration, 2018, "Compliance and Effects Modeling System." https://www.nhtsa.gov/corporate-average-fuel-economy/compliance-and-effects-modeling-system

[387] *Nic Lutsey, California's continued electric vehicle market development. May 7, 2018. https://www.theicct.org/publications/california-electric-vehicle-2018*

[388] *Peter Slowik and Nic Lutsey. The continued transition to electric vehicles in U.S. cities. July 24, 2018. https://www.theicct.org/publications/continued-EV-transition-us-cities-2018*

VI. Summary of attachments

We are enclosing the following reports as attachments to the comments submitted by the International Council on Clean Transportation:

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