ACEEE Comments to the Environmental Protection Agency and the National Highway Traffic Safety Administration on the Technical Assessment Report; Docket ID No. EPA-HQ-OAR- 2015-0827 and/or Docket No. NHTSA-2016-0068

The American Council for an Energy-Efficient Economy (ACEEE) strongly supports the agencies' fuel economy and greenhouse gas (GHG) emissions standards program for light-duty vehicles of model years (MY) 2012–2025. The standards already have spurred much technological progress in a thriving US automobile industry and improved fuel economy across all classes of cars and light trucks. Carrying the program through to 2025 and beyond will be crucial to advancing US energy and environmental goals, and the agencies' Draft Technical Assessment Report (TAR) confirms that the MY 2022-2025 standards set out in the final rulemaking on MY 2017–2025 (FRM) are achievable.

At the same time, ACEEE finds that the agencies can and should improve upon certain aspects of the program in the course of the Midterm Evaluation (MTE). The TAR provides much information that is helpful in understanding the opportunities for improvement, and below we offer our comments and recommendations accordingly. At the most general level, we are concerned that, due to increasing sales share of light trucks, fuel consumption and GHG emissions of MY 2017–2025 vehicles will be higher than projected in the FRM. It is clear from the TAR and other sources that the standards could be strengthened while maintaining the cost effectiveness of the program, even with fuel prices substantially below those in the FRM. Hence the MTE should seek to establish how best to recover, if not improve upon, the beneficial environmental outcomes anticipated in the FRM, despite market shifts toward larger vehicles.

All references in the comments below are to the TAR unless otherwise noted.

I. General Comments

Environmental outcomes of the standards

Table ES-1 of the TAR shows the change in the projected car/truck sales mix from the FRM to the TAR, and the resulting increase in average grams per mile for the 2025 fleet (175 g/mi, rather than the 163 g/mi anticipated in the FRM). Table ES-5 shows cumulative GHG and oil reductions from the 2021–2025 standards, but it is difficult to compare the environmental and energy outcomes of the program as estimated in the TAR to estimates in the FRM.

ACEEE estimated these changes in outcomes using Argonne National Laboratory's VISION model (2015 version). Our estimates reflect only the change in projected car/truck split; other possible changes such as an increase in average footprint of cars or trucks in a given year are not reflected in our analysis. We found that the reductions in GHG emissions and oil consumption due to the 2017–2025 standards, relative to a scenario in which the standards remained flat after 2016, were not substantially affected by the shift toward more trucks projected in the TAR. However, the lifetime emissions of the affected MY vehicles would increase substantially, with or without the increases in CAFE and GHG emissions standards, as a result of the higher projected truck share, as shown in table 1.

Based on the emissions levels shown in table 1, the increased emissions due to the sales shift toward trucks offsets 27% of emissions reductions delivered by the standards for MY 2017–2025 vehicles. If we consider instead GHG emissions in 2035 (table 2), assuming the standards remain at 2025 levels after MY 2025, the increase in emissions due to the sales mix shift is 14% of the emissions reduction due to the standards in that year.

Table 1. Lifetime CO_2 emissions of MY 2017–2025 light-duty vehicles (MMT)

	FRM car/LT shares	TAR car/LT shares	Mix shift effect
Reference case	12,272	12,843	571
Control case	10,218	10,772	554
GHG reductions	2,054	2,071	

Table 2. CO_2 emissions of MY 2017^{+} vehicles in 2035 (MMT)

	FRM car/LT shares	TAR car/LT shares	Mix shift effect
Reference case	1,344	1,408	64
Control case	988	1,041	53
GHG reductions	356	367	

The joint GHG/CAFE program seeks to address two complementary sets of priorities. The CAFE program is oriented toward reducing oil consumption, and doing so in a way that reduces consumer spending on transportation fuels. CAFE's current formulation as attribute-based standards addresses a key sticking point in earlier efforts to raise the standards, namely that manufacturers producing larger vehicles generally would need to spend proportionately more on vehicle technologies than those producing smaller vehicles. Consequently, while the program ensures that vehicles of all sizes achieve gains in fuel economy, the trajectory of total fuel consumption under the standards is uncertain, given the dependence of fuel consumption on the mix of vehicles sold.

The GHG standards address light-duty vehicles' role in lowering US emissions. Vehicle GHG standards should maximize light-duty vehicles' contributions to the absolute GHG emissions levels the United States seeks to achieve. If there is a cost-effective way to achieve lifetime emissions from the affected vehicles at or below the levels projected in the FRM, it is important that the standards deliver that outcome. These priorities can be fulfilled simultaneously if the agencies maintain footprint-based standards while adjusting the absolute levels of the standards to achieve a certain average CO_2 emissions rate. In particular, the footprint curve for a given year would be moved upwards in fuel economy by a certain factor, chosen to preserve the average fuel economy previously projected for that year. This would allow each manufacturer to sell a mix of vehicles meeting consumers' requirements, while also ensuring absolute progress toward GHG reduction by accelerating the adoption of vehicle technologies when sales shift toward larger vehicles. While accelerating technology adoption may raise costs to some degree, the standards that have been adopted thus far have fallen short of maximum cost-effective levels. The approach recommended here permits progress toward environmental goals while preserving the ability to respond to changing market demand.[1]

Technical foundation for the MTE

The purpose of the MTE is to determine whether the standards as adopted in the FRM are appropriate, should be weaker or stronger, or should be changed in other ways. By demonstrating in the TAR that, with updated technology and other assumptions, the standards can be achieved cost effectively, the agencies have ruled out the possibility that the standards are too stringent. The TAR does not however eliminate the possibility that the standards are not stringent enough, because it discusses only the feasibility of reaching the existing standards and not full technological potential, based on the agencies' updated technology assessment. Neither agency presents even a side case, like those presented in the FRM, examining compliance packages for more stringent standards. This analysis is essential for the determination the agencies are to make in the MTE. We believe there is substantial room for improvement, as discussed further below. In particular, additional cost-effective technologies, are available to raise the achievable levels substantially.

II. Technology Assessment

Engines

The agencies' compliance demonstration in the FRM was heavily dependent upon turbocharged, downsized engines. The emergence of additional engine technologies to complement turbocharging is among the most important additions that the TAR makes to the FRM analysis. In particular, high compression ratio (HCR), naturally aspirated engines achieve 44% penetration in EPA's control scenario for 2025 (Table ES–3). NHTSA shows negligible adoption of this and related technologies, however. While there is a benefit to the agencies' presentation of two very different pathways to meeting the 2025 standards, NHTSA's assessment of HCR and Atkinson cycle engines appears to suffer from limitations on the effectiveness and/or penetration of these engines that are not adequately explained in the TAR.

Additional engine technologies arriving in the vehicle market are mentioned in the TAR but missing from the agencies' assessment. Variable compression ratio (VCR) engines, for example, are due to enter the market in MY 2017, increasing fuel efficiency of turbocharged engines.[2] Electric turbochargers and superchargers are not yet in production but represent another pathway for cost-effective reductions in fuel consumption: the most recent National Research

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[1] It should be noted that any shifts towards larger vehicles that are an (unintended) byproduct of the standards' structure should be handled differently; see comments on pickup upsizing below.

[2] Nissan Global, "Infiniti VC-T: The world's first production-ready variable compression ratio engine," August 14, 2016. https://newsroom.nissan-global.com/releases/infiniti-vc-t-the-worlds-first-production-ready-variable-compression-ratio-engine; http://www.autoblog.com/2016/08/14/infiniti-vc-t-engine-variable-compression-official/ .

Council (NRC) fuel economy committee estimated that electrically assisted variable speed supercharger could deliver a 26% reduction in fuel consumption at $1,000-$1,300.[3] While some of these technologies may appear at this stage to be more complex or more expensive than currently available technologies, a multitude of ICE technologies and combinations of those technologies are developing rapidly and are likely to result in multiple options at least as cost effective as those represented in the agencies' analysis.

Mild hybrids

The emergence of new mild hybrid options, especially 48V mild hybrids, that achieve very substantial fuel economy improvements at far less than the cost of a full hybrid is an important consideration. Despite these advances, the penetration of mild hybrids in the agencies' 2025 compliance scenarios has declined from the levels found in the FRM, as we discuss further below. This suggests either that the standards can be achieved with substantially less technology than previously thought, or that the deployment of mild hybrids is constrained in some way in the compliance modeling process. In the case on NHTSA's analysis, we note that the penetration of mild hybrids in the light truck fleet reaches only 2% in 2030 (figure 13.36), even though this technology is already emerging today in the light truck market. We recommend that the agencies review their characterization of mild hybrid technology to ensure that the compliance modeling properly evaluates it likely role going forward.

Mass reduction

The agencies have updated their approaches to estimating the cost of mass reduction relative to the FRM, which is appropriate in view of the shortcomings of the FRM approach. The estimates are now based, at least in part, on the mass reduction teardown studies conducted by the agencies. The agencies have also created separate cost curves for cars and light trucks, which allows the possibility that load-carrying vehicles have different properties from non-load carrying vehicles with respect to mass reduction opportunities.

The mass reduction cost estimates for the GHG analysis involve averaging results of the EPA and NHTSA analyses, while the CAFE estimate uses only the results of NHTSA's analysis, which are higher than those of EPA. No explanation is offered for this discrepancy. Using the averaged results for both the GHG and CAFE analysis would eliminate one of many divergences between the agencies' analyses.

Need for a forward-looking approach to technology evaluation

There are several cases in which one or both agencies have likely underestimated the effectiveness or availability of fuel efficiency technologies, or overestimated their costs. Notable examples include HCR/Atkinson cycle engines, 48V mild hybrids, and mass reduction. Other technologies were omitted entirely. The agencies acknowledge this: "For example, the

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[3] National Research Council, **Cost, Effectiveness, and Deployment of Fuel Economy Technologies for Light-Duty Vehicles** (2015), Tables S-1 and S-2.

agencies were not able for this Draft TAR to evaluate the potential for technologies such as electric turbo-charging, variable compression ratio, skip-fire cylinder deactivation, and P2-configuration mild hybridization. These technologies may provide further cost-effective reductions in GHG emissions and fuel consumption" (p. ES–4). Furthermore. Both the long time frame associated with these standards and the changing nature of vehicle technology development must be taken into account in the MTE. The globalization of technology, product development, and markets tends to increase the cadence of product cycles, and the growing prevalence of computer-assisted design can substantially reduce the time required to develop and deploy many technologies. These factors should be reflected in the agencies' approach to determining the appropriate levels of the standards for MY 2022–2025.

The conservative nature of the agencies' analyses supports a very robust statement that the MY 2022-2025 standards are achievable and cost effective. However, this approach does not allow the TAR to be used as the technical basis for making a determination for the MTE, as it does not provide sufficient information or the best information for answering the question of whether the standards should be strengthened. Moreover, the analysis as it stands cannot guide the way to the next phases of the light-duty program. Hence additional technology assessment will be needed to complete the MTE.

Other technology assessment issues

EPA has done extensive teardown studies to estimate technology costs and continues to add to this body of work to update the estimates. The agency is to be commended for its commitment to this approach, which, while resource-intensive, is acknowledged to be the best approach to cost estimation. The NRC fuel economy committee "recognizes that such methods are expensive but believes that the added cost is well justified because it produces more reliable assessments."[4] The committee also noted that cost estimates obtained by surveying auto industry experts tend to yield high results.

Given the complexity of technology effectiveness and cost estimation in the TAR, and its importance to the MTE, it is essential that the agencies' findings be presented in a transparent fashion. Hence it is unacceptable that NHTSA does not provide effectiveness estimates explicitly in the TAR. NHTSA's approach to the modeling of technologies was problematic as well, in that it relied upon a simulation model that requires a license and work done on proprietary, and in some cases outdated, engine maps to determine technology fuel consumption benefits.

The agencies' differing approaches to retail mark-up accounts for a significant part of the difference in their technology costs, roughly $120 overall, based on table ES-2. While there is clearly substantial uncertainty in the technology-specific indirect cost multipliers (ICM) EPA uses to capture mark-up, ICMs are in principle preferable to the simplistic retail price equivalent (RPE) approach, as noted by the NRC.[5] We support the NRC committee's recommendation that

[4] NRC, **Cost, Effectiveness, and Deployment of Fuel Economy Technologies for Light-Duty Vehicles** (2015), p.3.
[5] Ibid, Finding 7.1.

the agencies continue their work to refine the assignment of ICMs to the various technologies, rather than settling for the RPE approach.

III. Analysis of the 2022-2025 Standards

A. EPA analysis

Technologies in control scenario

Some cost-effective technologies are absent from EPA's control scenario. EPA's projection for 2025 showed insignificant penetration of VVL (less than 3% in the control case) (table 12–31). NHTSA, by contrast, estimated significant penetration of this technology: 11% and 82% fleet penetration in 2015 and 2030, respectively (figure 13.34). This technology reduces pumping losses, improves air-fuel mixture, and improves thermodynamic efficiency (p. 5-18). VVL is applied together with VVT. This technology has been already applied by some OEMs. BMW has already implemented VVL across its offerings, while Toyota, Honda, and GM have applied it in segments of their production (p. 5–19). This is also one of the most cost-effective technologies, costing only $51 per % fuel consumption reduction for large pickups, less than the majority of engine, transmission, and vehicle technologies for light trucks.

The control scenario also shows a surprisingly low level of mass reduction: 6.3% for cars and 6.9% for light trucks. While we understand that these reductions are incremental to those already implemented in EPA's 2014 baseline fleet, the reductions for trucks in particular are unexpected, especially in view of current developments in the market. The NRC committee predicted that manufacturers will reduce the mass of midsize cars by 10% and of large vehicles by 20% or more, motivated both by the need to improve fuel economy and by the desire to improve vehicle handling and comfort. While we understand that the agencies' analysis is not a prediction, but rather a low-cost compliance scenario, the committee's observation is that mass reduction is happening and is driven in part by considerations other than fuel economy.

Similarly, despite the very positive account in Chapter 5 of developments mild hybrids, and in particular 48V systems, the technology finds relatively small application in EPA's control scenario. In the FRM, the compliance scenario included 26% penetration of mild hybrids in 2025,[6] at a cost of $1553–1642. Yet, in the TAR, EPA finds only 18.3% mild hybrids (table 12.33), despite a revised cost projection of $806 (p. 5-302).

The low penetration of these technologies in EPA's control scenario supports the hypothesis that significantly greater reductions in GHG emissions than are required by the MY 2022-2025 standards are achievable in this time frame.

Cars vs. light trucks in control scenario

In EPA's control scenario, cars on average fall short of (exceed) the standard by 2.6 grams per mile (gpm) and light trucks do better than their standard by 5 gpm in 2025 (table 12.4). For Ford and GM, which produce a higher percentage of large light trucks than the industry as a

[6] FRM table III-29.

whole, this difference between cars and light trucks is more marked: Ford cars exceed their target value by 16.2 gpm and GM cars by 19.8 gpm, and light trucks are below their targets by substantial, though lower, margins. These data suggest that trucks may have easier pathways to meeting the targets than cars do. This is not surprising in view of the modest improvements large light trucks are required to make in MY 2017-2021. This issue warrants further examination in the MTE, as the agencies consider whether to change the levels of the standards. In particular, it raises the question of whether the truck curves should be flattened to tighten the targets for large trucks. In response to comments on the FRM to this effect, the agencies expressed the concern that "manufacturers of large pickups would have limited options to comply with more stringent standards without resorting to compromising large truck load carrying and towing capacity."[7] EPA's control scenario in the TAR suggests the opposite.

B. NHTSA analysis

Vehicle miles traveled

NHTSA has updated its estimates of average VMT by cars and trucks (Section 13.1.4), which are used to calculate average annual and lifetime costs and savings. The new schedule predicts lower annual VMT for all ages after the first year, and a dramatic reduction in VMT starting in year eight (figure 13.5). The resulting difference in VMT over a 30-year life of a passenger car is a decrease of 96,882 miles under the new schedule—a 32% decrease from the previous schedule (table 13.1). Light-duty pickup lifetime miles decreased by 95,133 miles (26%) from the FRM. While these updates would not affect the Lifetime Vehicle Miles Traveled values used in the FRM to rationalize credit trading across cars and trucks, VMT reductions of this magnitude substantially increase the estimated payback period and reduce net lifetime consumer savings for the standards. ACEEE calculates that replacing NHTSA's VMT schedule with the one used by EPA in the TAR would reduce NHTSA's payback period by more than a year and increase net lifetime savings by over $500. In other words, the majority of the difference between the agencies' findings on consumer savings, as summarized in table ES-4, can be explained by differences in their choice of VMT projections.

NHTSA used IHS/Polk data in developing the proposed VMT reductions, noting the large sample size relative to that of the National Household Transportation Survey used to derive the VMT schedule in the FRM. NHTSA notes also however that the vehicles in the Polk data set "would have experienced prolonged periods of both fuel price instability and economic distress (the years from 2007-2010, though continuing longer for certain age cohorts that remained chronically underemployed for a longer period of time)—perhaps depressing VMT relative to today" (p. 13-21). NHTSA also cites the strong pre-recession economy as a reason that using NHTS data might lead to overestimates of future VMT.

In cases such as this, in which there is substantial uncertainty associated with the projection of economic parameters, agencies should rely to the extent possible on standard sources, as is done in the case of future gasoline prices by citing the Energy Information Agency's *Annual*

[7] FRM p. 62691.

Energy Outlook (AEO). EPA's approach to VMT appears to be more in line with other federal estimates. EPA made minor VMT adjustments in the TAR relative to FRM VMT values, based on VMT schedules in the MOVES model, which in turn draw from FHWA data and the AEO, as well as Polk data (p.10–6). This is an area in which EPA and NHTSA should seek to use common assumptions, as discrepancies in this area make it more difficult to understand the agencies' findings on subjects more central to the analysis of vehicle improvement potential. The effects of deviation from the common projection of VMT could then be explored through a sensitivity analysis, if appropriate.

Treatment of the ZEV mandate

In its reference case, EPA includes some EVs representing sales of vehicles in California and section 177 states to meet the requirements of the ZEV mandate: 2.1% BEVs and 1.7% PHEVs (Table 12.27). This is nearly the full complement of EVs in EPA's compliance scenario, 2.6% EVs and 1.7% PHEVs (Table 12.33). NHTSA on the other hand includes no EVs in its reference case; we found no explanation for this choice. NHTSA does however show 2% BEVs and 1% PHEVs in the compliance scenario (figure 13.32). Hence NHTSA finds that the number of EVs in the compliance scenario that result from the MY 2022-2025 standards is substantially higher than EPA finds. While the percentage of EVs nationally projected for 2025 is modest with or without the ZEV mandate, the incremental cost of EVs remains high enough that their inclusion in, or exclusion from, the reference case will have a substantial impact on the estimated average cost of meeting the standard. Given that NHTSA's analysis is a "real-world" analysis and not a "standards-setting" analysis (p.13–58), NHTSA's assumptions should reflect best estimates of what will happen in the vehicle market and need not reflect statutory limitations on what factors can be considered in setting standards. Hence, we recommend that NHTSA include ZEV mandate vehicles in estimating the cost of meeting the 2021–2025 standards.

Performance increases and vehicle platforms

The agencies reference the 2012 National Academy of Sciences fuel economy report statement that "objective comparisons of the cost-effectiveness of different technologies for reducing [fuel consumption] can be made only when vehicle performance remains equivalent" (p.5–48). The agencies also note the particular importance of this principle for advanced transmissions (p. 5-48). Subsequently, EPA states: "Thus, the costs and effectiveness presented in this document are based on the application of technology packages while holding the underlying acceleration performance constant" (p. 5-224).

NHTSA does not adhere to this principle, however. NHTSA's applications of transmission technologies and low levels of mass reduction (under 10%) both lead to increases in vehicle performance, and those technologies consequently fall short of their potential for fuel-efficiency gain. In fact, this appears to be a significant reason for the discrepancy between the two agencies' cost of compliance. NHTSA's rationale for allowing performance increases in such cases is that manufacturers will not take advantage of a relatively small opportunity for better fuel economy if it entails the redesign of the vehicle or powertrain, especially when the vehicle shares a platform with others to which the design change may not apply (p. 13–66).

To get a sense of the overall effect of this approach, we used Volpe model output files to compare the average power-to-weight ratio of vehicles in 2028 with and without increases in CAFE standards. The compliance fleet in 2028 showed an increase in power-to-weight ratio of 4.1% for cars, 7.9% for light trucks, and 5.5% overall.[8] In rough terms, NHTSA's approach in effect required manufacturers to pay for an additional year of fuel economy improvements, and nearly two additional years for light trucks, in order to accommodate these performance increases.

NHTSA references the costs incurred by a manufacturer with the proliferation of engines and transmissions. Increasingly, however, manufacturers design for global platforms serving a much larger market than the US market alone. This could reduce the cost associated with the development of new engines and transmissions and/or allow for cost-effective development of a greater number of powertrains which could be better tuned to specific demands for fuel economy or other characteristics. Indeed, the 2015 NRC report, in discussing the impact of global platforms, noted both potential constraints and potential opportunities associated with this trend: "The platform design might limit the ability to implement some changes but expedite the implementation of others that fit within the standard design, reducing development costs."[9] Hence the restriction in the Volpe model that "engines and transmissions that are shared between vehicles must apply the same levels of technology, in all technologies," should be reviewed.

The proliferation of engines in a manufacturer's line-up can be costly, and consequently changes elsewhere in a vehicle may not be immediately accompanied by engine re-optimization. At the same time, the process of vehicle design is accelerating and becoming more flexible. Increasing levels of automation, capabilities of computer-assisted engineering, as well as the pressures and opportunities of expanding global vehicle markets, are likely to result in more frequent whole-vehicle optimization, including appropriate sizing of the engine and other vehicle components. At present, vehicles may include features and specifications beyond those demanded by individual buyers. Manufacturers have not found it in their interest to tailor vehicles to individual buyers, but a "mass customization" approach enabled by new technology make such tailoring possible.

In this environment, NHTSA's constraints on engine size, which lead to increased performance in certain cases, do not seem warranted. Similarly, constraints on technology adoption that NHTSA imposes through platform sharing may be inappropriate for analyzing a compliance scenario a decade in the future.

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[8] ACEEE inadvertently used the "standard setting" rather than "real world" output files for this comparison. This could modestly change the result but is unlikely to change the finding substantially.

[9] National Research Council, **Cost, Effectiveness, and Deployment of Fuel Economy Technologies for Light-Duty Vehicles** (2015), p. 259.

Compliance scenario

In its evaluation of technologies to meet the 2025 standards, NHTSA finds negligible (<1%) adoption of HCR engines, while EPA's scenario includes 44% adoption of this technology (table ES–3). This discrepancy calls for further explanation, especially in view of the rapid advances in this and related engine technologies and NHTSA's incomplete description of how they modeled its adoption. In the case of the basic engine path, if a vehicle continues with application of cylinder deactivation, NHTSA's model disables the HCR and HCRP technologies (p. 13–43). While this logic may be suitable for trucks with OHV engines, where cylinder deactivation provides substantial fuel economy gains, it is not appropriate for vehicles with SOHC/DOHC engines, for which cylinder deactivation benefits are low. Since the HCR engine provides one of the most cost-effective fuel consumption reduction options, manufacturers of DOHC/SOHC engines may find it suitable for their vehicles, but NHTSA's analysis assumes otherwise. This assumption may be attributable to NHTSA's acquisition of a commercial forecast from IHS/Polk that reflects decisions manufacturers will make in complying with standards only through MY 2021 (p. 13-8). HCR engines have already appeared—for example, Mazda's SkyActiv engine—and therefore this technology should be part of the 2025 compliance package both for cars and light trucks.

Unlike EPA, NHTSA finds that the large OEMs' cars and light trucks separately meet the 2025 standards, at least by MY 2030 (table 13.8). That is, no transfer of credits between car and light truck fleets is required. It is unclear however whether this results from a constraint placed on the compliance model. If so, this may have inflated NHTSA's estimate of the cost of meeting the standards in the "real-world" assessment.

Technology packages for full size pickups in 2028

In order to better understand NHTSA's analysis, ACEEE looked in detail at the technology packages for Detroit manufacturers' large pickup trucks in the Volpe model. The technology penetration for these trucks in NHTSA's 2028 compliance scenario is shown in figure 1.

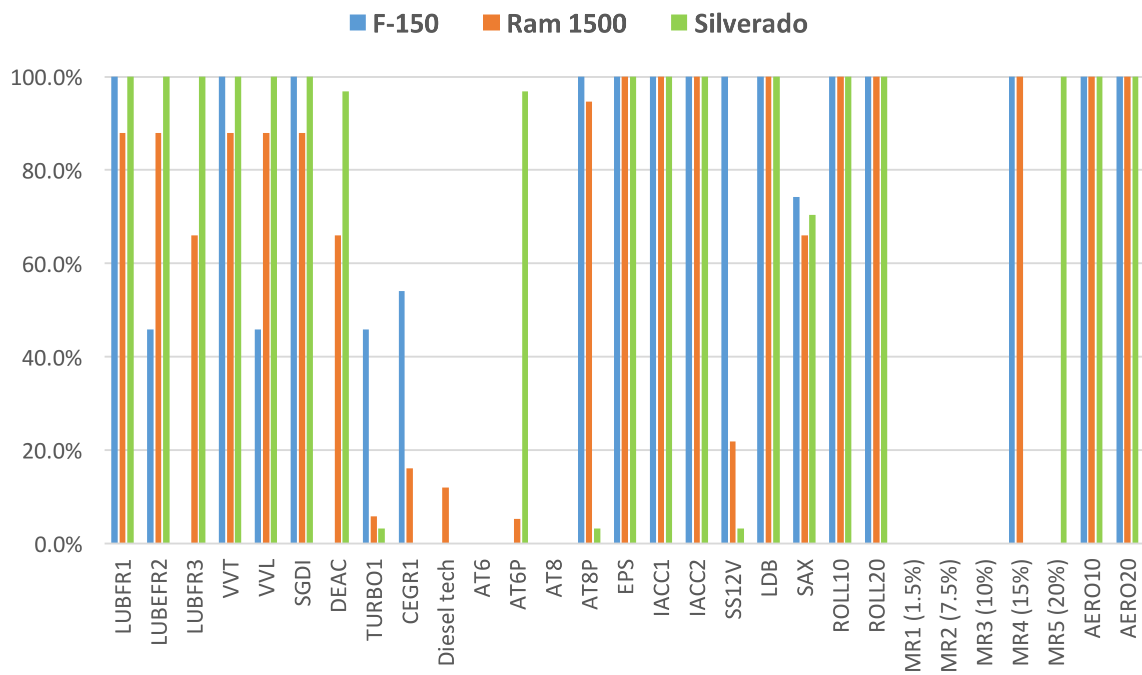

Figure 1: NHTSA's technology penetration for selected full size pickups in MY 2028

NHTSA's compliance packages do not appear to show the most cost-effective pathways to compliance. For example, while there are 8-speed transmissions in almost all F-150 and Ram pickups in 2028, only 3% of Silverado trucks have them, the same percentage as in the 2015 baseline fleet. This is all the more surprising given that an 8-speed transmissions is already available in the high-volume 5.3L Silverado in MY 2016 and has been standard in models with the 6.2L engine for years.[10]

On the other hand, Volpe outputs show 100% of MY 2028 Silverado trucks with 20% mass reduction in 2028. Mass reduction will play a critical role for compliance for trucks, and all F-150 and Ram trucks, as well as the Silverado, will adopt 15% mass reduction by 2021, according to the model. But NHTSA's cost estimates for mass reduction increase sharply at higher percent reduction, so increasing mass reduction to 20% in the Silverado before even adopting 8-speed transmissions is not plausible. Increasing mass reduction from 15% to 20% provides 3% fuel savings at a total cost of $1,000 (p. 5–411), while an advanced 8-speed "plus" transmission (AT8P) gives 9% savings at a cost of $320 (p. 5–298, p. 5–452).

The NHTSA compliance scenario also shows no hybrids, full or mild, in the F-150, Ram, or Silverado, even 48V mild hybrid provides fuel savings in the vicinity of 10% at a cost of about $100 per percent fuel savings (pp. 5–301, 5–454). As noted previously, NHTSA does not explain its mild hybrid specifications or any limitations the Volpe model may place on adoption of this technology in the TAR, so it remains unclear why these vehicles do not appear in the

[10] http://www.automobilemag.com/news/2016-chevrolet-silverado-offers-8-speed-automatic-with-5-3-liter/.

compliance scenario. Yet both GM and Ram have already announced mild hybrids for their pickup offerings.[11,12] The eAssist in Sierra/Silverado trucks, a $500 option, is projected to reduce annual fuel costs from $2050 to $1850.

These results raise the question of whether constraints in the Volpe model may prevent identification of the least cost solutions for compliance. They also suggest that further opportunities exist to exceed the augural standards at reasonable cost, at least in some vehicle classes. These opportunities need to be fully investigated in the MTE.

Alternative fuel economy improvement scenarios

NHTSA's Volpe modeling includes important scenarios not discussed in the Draft TAR. As noted previously, the agencies need not only to verify that the standards in the FRM are feasible, but also to determine whether they should be more stringent. ACEEE ran the Volpe model with input files for rates of improvement exceeding the rate of increase in the augural standards (approximately 4% per year) and found that net social benefits increased with a higher rate of improvement. Specifically, for MY 2022–2028 vehicles, net benefits calculated by the model were highest at 6% per year, as shown in table 3.[13]

Table 3. Net benefits of various fuel economy improvement scenarios (MY 2022–2028)

	Net benefits ($ billion)
Augural standards	$85
6% per year improvement	$112
8% per year improvement	$88
10% per year improvement	$65

While not dispositive, these results corroborate that the agencies need to investigate the possibility that standards for MY 2022–2025 should be more stringent than the augural standards.

IV. Other Issues

Pickup upsizing

The FRM assumed that vehicle footprint generally would remain constant over time. This assumption has not proven accurate for trucks: the average footprint of pickup trucks increased

[11] https://www.fcagroup.com/en-US/investor_relations/events_presentations/quarterly_results_presentations/FCA_2014_18__Business_Plan_Update.pdf, p.17.

[12] http://media.gmc.com/media/us/en/gmc/news.detail.html/content/Pages/news/us/en/2016/feb/0225-sierra-eAssist.html.

[13] See footnote 9. The same caveat applies here.

by almost 3.2 sq. ft., to about 66 sq. ft., between 2008 and 2015 (p. 3–92). This increase is already sufficient to lower the fuel economy target for these vehicles by 1.3 miles per gallon in 2025.

In addition to the increase in absolute emissions and fuel consumption associated with an increase in vehicle size, there is ongoing debate over the question of whether the standards themselves incentivize the upsizing of vehicles. The agencies "believe that [changes to footprint] are significant enough to be unattractive as a measure to undertake solely to reduce compliance burdens" (p. 8-62). This question warrants further scrutiny, and perhaps an analysis by vehicle type, especially in view of manufacturers' demonstrated ability to increase footprint simply by pushing the wheels of some vehicles closer to the corners without changing the shadow of the vehicle.

A related topic that warrants further exploration is the effect of the changing light truck "cut point," a footprint value above which the standards are constant. In the 2012–2016 rule, the agencies set a cut point for light truck standards, finding that "[l]imiting the [GHG emissions target] function's value for the largest vehicles leads to a function with an inherent absolute minimum level of performance, while remaining consistent with safety considerations."[14]

This cut point was set at 66 sq. ft. for light trucks in the 2012–2016 rule. In the 2017–2025 rule, however, the agencies increased the cut point over time, and it now stands at 74 sq. ft. for MY 2022 and beyond. The agencies' rationale for this change was in part that the 66 sq. ft. cut point would disadvantage manufacturers of trucks of larger footprint as the stringency of standards increased.[15] With the increase in pickup footprint over time, the agencies must consider also the reasons for and impacts of having more pickups in this larger footprint range.

Footprint-based standards were adopted to accommodate changes in the vehicle market and address safety concerns. These issues have different implications for the largest pickups than for the market as a whole, however, as discussed above. We recommend that the agencies undertake a data-based investigation of impacts of the shape of the footprint curves on manufacturers' footprint distributions, particularly in the vicinity of the upper cut point. Maintaining the upper cut point at 66 sq. ft. should be reconsidered as an option.

Reference case

EPA assumes that vehicles' GHG emissions would not decline beyond the levels in the 2021 standards in the absence of further tightening of the standards and explains why projected conditions support that assumption (p. 4-27). It is not clear that NHTSA adopts this assumption. The Volpe model assumes that after achieving compliance with CAFE standards, "the manufacturer treats all technologies that pay for themselves within the first year of ownership as having a negative effective cost" (p. 13–10). This suggests that the Volpe model may find that vehicles' fuel economy may increase absent an increase in standards. NHTSA should clarify this

[14] MY 2012-2016 final rule p. 25359.
[15] FRM p. 62699.

point and justify any deviation from the agencies' practice in the FRM to maintain a flat fuel economy reference case in the main analysis.

In setting the 2017–2025 standards, the agencies assessed what fuel economy could be achieved by adding technologies to vehicles while keeping their "performance" constant. Yet average horsepower, especially that of pickups, has increased since the FRM (figure 3.6). In reviewing the validity of the FRM analysis, the MTE should ask whether the 2025 standards are achievable for vehicles having the performance characteristics assumed in the FRM, not the performance of an updated fleet. That manufacturers have increased horsepower over this period and the agencies nonetheless found in the TAR that the standards could be met cost effectively indicates that the standards were not the maximum feasible.

The adoption of footprint-based standards reflects the view that size is fundamental to the utility of a vehicle and is therefore an attribute best left to the market. No such adjustment is made for horsepower; a manufacturer that increases its percentage of high-performance vehicles is not entitled to a more lenient standard. Similarly, a manufacturer that chooses to increase horsepower over time should not expect standards to be adjusted to accommodate that decision.

Standards' role in accelerating technology development

The agencies do not make a strong claim regarding the role of the standards in driving efficiency technology advances. The literature the agencies cite on this topic is inconclusive, but it is for the most part not recent enough to reflect developments in vehicle technology since the adoption of the 2012-2025 standards. These standards are in fact widely viewed in the industry as strongly influencing technology advances. A representative of Corning recently observed: "Without regulation, it takes 20 years for new technology to get 80% penetration. With it, it can be virtually instant."[16] In a recent report, the Center for Automotive Research states: "It should be needless to point out that the fuel economy mandates have resulted in an unprecedented acceleration in the pace of product development and technology deployment, especially in powertrain and the use of new materials."[17]

The TAR advances the theory that the market drives incremental technology improvement, while the standards drive major innovation. While we agree that California's ZEV program has been a major factor in the development and deployment of EVs and other advanced powertrain vehicles, federal standards appear to be far more closely tied thus far to advances in conventional technologies.

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[16] Tim Johnson. ICCT Conference "Driving Automotive Innovation." September 13, 2016. Washington, DC.

[17] "The Potential Effects of the 2017-2025 EPA/NHTSA GHG/Fuel Economy Mandates on the U.S. Economy." Center for Automotive Research (2016). Footnote, p.14.

Off-cycle credits

The agencies state: "The intent of the off-cycle provisions is to provide an incentive for CO_2 and fuel consumption reducing off-cycle technologies that would otherwise not be developed because they do not offer a significant 2-cycle benefit" (p 5–219). We welcome this clarification regarding the purpose off-cycle credits.

The TAR notes the interest of the Alliance of Automobile Manufacturers (AAM) and others in the industry in "harmonizing" certain provisions of the EPA and NHTSA programs (p. 11–9). AAM filed a petition to NHTSA and EPA on a number of such matters in June 2016.[18] In addition to the statutory limitations on the CAFE program, mentioned in the TAR, that preclude NHTSA from adopting certain provisions of the EPA program, there are other reasons that certain requests in the petition cannot or should not be granted. In particular, retroactive credits do nothing to incentivize new technology and simply reduce fuel savings from the standards by providing credits that manufacturers can carry forward to postpone adoption of efficiency technologies. Also, as NHTSA noted in the FRM, "if manufacturers are able to achieve improvements in mpg that are not reflected on the test cycle, then the level of CAFE that they are capable of achieving is higher than that which their performance on the test cycle would otherwise indicate, which suggests, in turn, that a higher stringency is feasible."[19]

The petition also calls for an "improved" off-cycle credit approval process. Having a navigable off-cycle credit approval process is desirable; otherwise the standards cannot help bring these technologies into the fleet. However, an off-cycle technology that is common in current vehicles and is not reflected in the stringency of standards has no place in the off-cycle credit program. The purpose of the program is to incentivize adoption of fuel saving technology, not to provide loopholes for manufacturers to achieve the standards on paper. Furthermore, default approval of applications not acted on within a fixed time period, as requested by the petitioners, is not reasonable. The default action clearly should be the award of no credits for an off-cycle technology. Off-cycle credits are to be awarded only based on a credible technical demonstration that the technologies will provide benefits in the real-world, which is typically a complex, data-heavy undertaking. The viability of the off-cycle program depends on the credibility of the evidence that the credits are deserved. Petitions for credits under the program to date have contained claims and analyses that were contested by multiple commenters, and EPA itself has found that only some of the requested credits were warranted.

The agencies note that innovations including connected and automated vehicles could have "a very profound impact" on transportation system efficiency and on GHG emissions, but that their net result could be either an increase or a decrease in emissions (p. 3-22). In a recent Transportation Research Board conference, a senior official at the US Department of Energy (DOE) described preliminary research conducted by the DOE National Laboratories that

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[18] AAM and Global Automakers. "Petition for Direct Final Rule with Regard to Various Aspects of the Corporate Average Fuel Economy Program and the Greenhouse Gas Program." June 20, 2016.

[19] MY 2012-2016 final rule p. 25663.

indicated a possible 90% reduction in the 2050 baseline energy consumption from connected, autonomous, and other technologies. He noted, however, that the research also indicated a potential 200% increase in 2050 energy consumption, depending on how these vehicles affect travel behavior, vehicle miles traveled (VMT), and other factors.[20]

Hence we concur with the agencies' observation that it is difficult to assess the likely impact of such vehicles, especially in the 2022–2025 timeframe. The FRM specifies that, in order to be eligible for credits, "the manufacturer would have to develop a robust methodology, subject to EPA approval, to demonstrate the benefit and determine the appropriate CO_2 gram per mile credit." Consequently, it is not appropriate to assign emissions credits to such technologies under the standards. In fact, uncertainty regarding the emissions impacts of such technologies is not the only reason to preclude them from the program; the FRM also expressly prohibited credits for "technologies which provide those improvements by indirect means […] or may provide benefit to other vehicles on the road more than for themselves."[21] Indeed, the fuel economy and GHG emissions standards are based on an approach focused on the vehicle's performance as measured in specified, repeatable conditions. Folding a range of other factors external to the vehicle into the program is inconsistent with this approach. A separate program of requirements and incentives for automated and connected vehicles, if appropriate, will likely be a sounder way of achieving the desired outcomes.

V. Conclusions and Recommendations

The TAR lays an essential technical foundation for the MTE of CAFE and GHG standards out to 2025. While several significant differences exist between the NHTSA's and EPA's analyses, both agencies find that the MY 2022–2025 standards are achievable and deliver net consumer benefits.

The agencies do not however attempt to determine whether the standards should be strengthened. There is ample evidence in the TAR that the compliance scenarios presented there fall short of deploying all cost-effective technologies. Thus additional analysis of technological potential will be necessary as input to the MTE. The agencies' MTE schedule sets a proposed determination (EPA) and proposed rule (NHTSA) no later than mid-2017, so this additional analysis, along with the agencies' evaluation of and response to the comments on the TAR, should be completed in the current calendar year.

That the agencies used two largely independent analyses and reached similar conclusions provides evidence of the robustness of those conclusions. However, there are various elements of the agencies' analyses that lie outside the core assessment of technology cost and effectiveness, and for these elements, disparities between the agencies serve only to obscure

[20] http://onlinepubs.trb.org/onlinepubs/conf/CPW19.pdf.
[21] https://www.federalregister.gov/articles/2012/10/15/2012-21972/2017-and-later-model-year-light-duty-vehicle-greenhouse-gas-emissions-and-corporate-average-fuel.

the findings. These include such matters as projections of VMT, baseline fleet, and retail markup. These matters, like future oil prices, are important to the setting of standards, but uncertainties about them are best handled through sensitivity analyses outside the compliance modeling.

Several recommendations on specific issues are offered throughout these comments. Our more general recommendations are as follows:

- The agencies should create a more comprehensive and forward-looking technology analysis to show likely advances in technology effectiveness and additional technologies that will be available.
- In the next stage of the MTE (and preferably in response to comments), the agencies should expand their analyses to evaluate the costs and benefits of complying with more stringent standards for 2021-2025 than those set out in the FRM.
- The agencies' analysis should explicitly consider the potential to compensate for additional emissions and fuel consumption associated with market shifts toward larger vehicles.
- For as many factors as possible and including all factors outside the core technology analysis, the agencies should settle upon common assumptions, based to the extent possible on standard data sources. Where important uncertainties exist, these issues can be pursued through sensitivity analyses.

Addendum to ACEEE Comments to the Environmental Protection Agency and the National Highway Traffic Safety Administration on the Technical Assessment Report; Docket ID No. EPA-HQ-OAR- 2015-0827 and/or Docket No. NHTSA-2016-0068

November 17, 2016

In our comments of September 26, 2016, ACEEE drew certain conclusions regarding NHTSA's compliance scenario from running the Volpe model. As noted in footnotes 8 and 13 of those comments, we used the "Standard Setting" Volpe settings for this purpose in two cases in which the "Real World" settings would have been more appropriate. This addendum is to revise our comments based on model runs using the correct (i.e. Real World) settings. We note that ACEEE's comments on NHTSA's pickup truck technology utilization in 2025 remain unchanged, because in that case we referenced results based on the Real World settings in our original comments.

Power-to-Weight Ratio

In discussing the consequences of NHTSA's allowing vehicle "performance" to increase in its compliance scenario modeling, we stated (p. 9 of ACEEE TAR comments) that the average power-to-weight ratio in the compliance scenario increased relative to the reference case by 4.1% for cars, 7.9% for light trucks, and 5.5% overall. Using the Real World settings, the power-to-weight ratio in 2028 instead increases by 4.0% for cars, 7.4% for light trucks, and 5.5% overall. Hence our conclusion remains unchanged. We reference MY2028 due to NHTSA's identification of MY2028 as the year in which the new vehicle fleet reaches the MY2025 standard through tested fuel economy alone.

Net Benefits

Table 13.25 in the draft TAR provides the estimated present value of costs, benefits, and net benefits, over the lifetimes of MY 2016-2028 vehicles, of the MY 2022-2025 standards relative to continuation of the MY 2021 standard. NHTSA finds an $85 billion net benefit from the augural standards. However, using the Volpe model to run other stringencies, we found even greater net benefits from more stringent alternative scenarios.

In our TAR comments, we stated (p.12) that the 6% per year improvement provided the largest net benefits, based on Standard Setting runs. Here we discuss the results using the Real World settings instead, in order to provide the proper comparison with the analysis in the draft TAR. The Real World runs show maximum benefits at even higher rates of improvement, based on benefit and cost outputs from the Volpe model. We used discounted technology costs and maintenance costs from the Volpe "compliance report" and crashes, fatalities, congestion, noise, fuel savings, refueling time, energy security, increased mobility, and pollutant aspects from the "societal costs report". As shown in the table below, maximum net benefits of MY 2022-2025 standards for MY 2016-2028 vehicles occur at 9% per year improvement in fuel economy. The net benefit at 9% per year is $145 billion, compared with $85 billion for the augural standards.

Net Benefits of MY 2022-2025 Standards over Lifetime of MY 2016-2028 Vehicles

Scenario	Net Benefit ($b)
%/year improvement	
Augural	$ 85
6%	$ 116
7%	$ 124
8%	$ 136
9%	$ 145
10%	$ 142
11%	$ 133
12%	$ 92

Source: ACEEE Volpe model runs

We computed these benefits over the lifetime of MY 2016-2028 vehicles in order to provide a basis for comparison across scenarios. However, standards set at higher rates of increase "stabilize" later, in the sense used by NHTSA in the draft TAR (i.e., the fleet meets the standard based on achieved average miles per gallon alone. While the 9% per year scenario does not stabilize within the time horizon of the Volpe model runs (MY 2032), scenarios of 6% and 7% per year improvement do so, and 8% per year very nearly does so, falling 0.029% short, as shown in the table below.

Percent Shortfall/Overcompliance with Standards by Model Year,
Volpe Model Runs with Real World Settings

	Achieved vs. Standard MPG							
MY	**Augural**	**6%**	**7%**	**8%**	**9%**	**10%**	**11%**	**12%**
2015	-0.31%	-0.31%	-0.31%	-0.31%	-0.31%	-0.31%	-0.31%	-0.31%
2016	-1.78%	-1.78%	-1.78%	-1.74%	-1.65%	-1.64%	-1.63%	-1.62%
2017	-0.61%	-0.59%	-0.59%	-0.49%	-0.38%	-0.37%	-0.13%	-0.10%
2018	1.94%	2.45%	2.82%	3.31%	3.62%	3.90%	4.28%	4.68%
2019	3.18%	4.23%	5.07%	5.90%	6.44%	6.82%	7.26%	7.98%
2020	4.02%	5.52%	6.59%	7.86%	8.95%	9.82%	10.65%	11.67%
2021	4.94%	7.43%	8.91%	10.78%	12.68%	14.57%	15.89%	17.43%
2022	3.63%	5.46%	6.35%	7.70%	9.13%	10.70%	11.73%	12.61%
2023	1.61%	2.48%	2.85%	3.63%	4.34%	5.13%	5.30%	5.84%
2024	-1.01%	-0.85%	-1.18%	-1.03%	-1.21%	-1.38%	-2.16%	-2.08%
2025	-3.04%	-3.88%	-5.03%	-6.23%	-7.05%	-7.70%	-9.44%	-8.78%
2026	-1.30%	-1.84%	-2.83%	-4.08%	-4.85%	-5.53%	-7.16%	-6.74%
2027	0.42%	-0.26%	-1.16%	-2.26%	-2.71%	-3.12%	-4.51%	-4.54%
2028	**1.14%**	0.37%	-0.32%	-1.23%	-1.72%	-2.06%	-2.49%	-2.85%
2029	1.45%	**0.85%**	0.27%	-0.44%	-0.91%	-1.50%	-1.85%	-2.08%
2030	1.67%	1.06%	**0.45%**	-0.26%	-0.67%	-1.29%	-1.51%	-1.67%
2031	1.90%	1.26%	0.67%	-0.029%	-0.41%	-1.04%	-1.27%	-1.37%
2032	1.90%	1.26%	0.67%	**-0.029%**	-0.41%	-1.05%	-1.27%	-1.38%

Source: ACEEE Volpe model runs

Over the lifetime of MY 2016-2032 vehicles, the 8% per year improvement scenario provides maximum net benefits among scenarios that stabilize by that year. The table below compares maximum net benefits under various percent per year improvement scenarios, across three groups of model years: MY 2016-2028 (used in the draft TAR), MY 2022-2025 (the model years nominally covered by the augural standards), and MY 2016-2032 (by which time several scenarios will have stabilized).

Net Benefits of MY 2022-2025 Standards over Lifetime of Three Vehicle Groups

	Net Benefit ($b)		
Scenario	**MY 2016-2028**	**MY 2022-2025**	**MY 2016-2032**
%/yr. improvement			
Augural	$ 85	$ 36	$ 134
6%	$ 116	$ 48	$ 177
7%	$ 124	$ 50	$ 182
8%	$ 136	$ 58	**$ 198**
9%	**$ 145**	$ 63	*
10%	$ 142	$ **64**	*
11%	$ 133	$ 60	*
12%	$ 92	$ 45	*

Source: ACEEE Volpe model runs

* No value provided for these scenarios because this column is meant to compare only those scenarios that have stabilized by 2032.

For all vehicle groups considered, maximum net benefits occur for a scenario in which the rate of fuel economy increase greatly exceeds the rate in the augural standards. Hence we reaffirm this statement in ACEEE's original comments: "While not dispositive, these results corroborate that the agencies need to investigate the possibility that standards for MY 2022–2025 should be more stringent than the augural standards."