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Submitted electronically to www.regulations.gov and 2016TAR@arb.ca.gov.

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CARB – http://www.arb.ca.gov/msprog/levprog/leviii/2016tar.htm

Alliance of Automobile Manufacturs Comments on Draft Technical Assessment Report: Midterm Evaluation of Light-Duty Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards for Model Years 2022-2025 (EPA-420-D-16-900, July 2016)

Dear Mr. Lieske, Ms. Yoon, and Mr. McCarthy,

I am submitting the enclosed comments and associated attachments on behalf of the Alliance of Automobile Manufacturers[1] (Alliance) in response to the subject Draft Technical Assessment Report.

The Alliance supports the One National Program (ONP) and its goals of reducing greenhouse gas (GHG) emissions and improving the corporate average fuel economy (CAFE) of light-duty vehicles via harmonized federal and state regulations.

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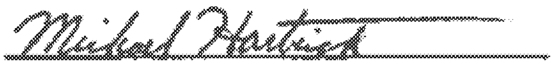
[1] The Alliance of Automobile Manufacturers, is an association representing 12 manufacturers of cars and light trucks. Alliance members are BMW Group, FCA US LLC, Ford Motor Company, General Motors Company, Jaguar Land Rover, Mazda, Mercedes-Benz USA, Mitsubishi Motors, Porsche Cars North America, Toyota, Volkswagen Group of America, and Volvo Car USA. For more information, please visit: www.autoalliance.org.

Your consideration of these comments and attachments is appreciated. If you have any questions on this matter, please contact me at (248) 357-4717, extension Ex. 6 or at MHartrick@autoalliance.org.

Sincerely,



Michael Hartrick
Director of Fuel Economy & Climate
Alliance of Automobile Manufacturers

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List of Acronyms

0-D	zero dimensional
1-D	one dimensional
2010 FRM	2010 final rulemaking – 75 Fed. Reg. 25324 (May 7, 2010).
2012 FRM	2012 final rulemaking - 77 Fed. Reg. 62623 (Oct. 15, 2012).
2WD	two-wheel drive
4WD	four-wheel drive
AAA	American Automobile Association
AAPC	American Automotive Policy Council
Advanced Atkinson Tech Package	non-hybrid Atkinson engine with cooled EGR and cylinder deactivation
A/C	air conditioning
ADA	Americans with Disabilities Act
AHSS	advanced high strength steel
AEO	Annual Energy Outlook
Agencies	U.S. Environmental Protection Agency and National Highway Traffic Safety Administration
Alliance	Alliance of Automobile Manufacturers
ALPHA	EPA's Advanced Light-Duty Powertrain and Hybrid Analysis
ANL	Argonne National Laboratory
ATK2	Atkinson cycle engine in a non-hybrid application
AWD	all-wheel drive
BEV	battery electric vehicle
BISG	belt integrated starter generator
BIW	body-in-white
BMEP	brake mean effective pressure
BSFC	brake specific fuel consumption
CAA	Clean Air Act
CAFE	Corporate Average Fuel Economy
CAR	Center for Automotive Research
CARB	California Air Resources Board
C_d	coefficient of drag
C_dA	the product of the coefficient of drag and frontal area
CEC	California Energy Commission
CEGR	cooled exhaust gas recirculation

CISG	crank integrated starter generator
CNG	compressed natural gas
CO_2	carbon dioxide (interchanged with greenhouse gas in many cases)
COP	coefficient of performance
CR	compression ratio
CVT	continuously variable transmission
CVVL	continuously variable valve lift
cyl	cylinder
DC	direct current
DCT	dual clutch transmission
DEAC	cylinder deactivation
D/M	engine displacement to vehicle mass ratio
DMC	direct manufacturing cost
DOHC	dual overhead cam
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EER	effective expansion ratio
EGR	exhaust gas recirculation
EIA	United States Energy Information Administration
EMF	electromagnetic frequency
EPA	U.S. Environmental Protection Agency
Estimator	EPA's Vehicle Energy Effects Estimator tool
ETW	equivalent test weight
E.U.	European Union
EV	electric vehicle
EVDC	externally controlled variable displacement compressor
FARS	fatality analysis reporting system
FCV	fuel cell vehicle
FE	fuel economy
FWD	front wheel drive
GHG	greenhouse gas
GDI	gasoline direct injection
GDP	gross domestic product
Global Automakers	The Association of Global Automakers, Inc.
GREEN	Global Refrigerants Energy and Environmental
GTDI	gasoline turbocharged direct injection
GUI	graphical user interface

GWP	global warming potential
HEG2	high efficiency gearbox level 2
HEV	hybrid electric vehicle
IAV	IAV Automotive Engineering
ICE	internal combustion engine
IHX	internal heat exchanger
IMAC	improved mobile air conditioner
ISOR	initial statement of reasons
IU	Indiana University
KAPSARC	King Abdullah Petroleum Studies And Research Center
LCCP	Lifecycle Climate Change Performance
LHV	lower heating value
LIVC	late intake valve closing
LPCEGR	low pressure cooled exhaust gas recirculation
LPM	Lumped Parameter Model
LWV	Light-weight vehicle
MAC	mobile air conditioning
MDPV	medium-duty passenger vehicle
MBT	mean best torque
MTE	midterm evaluation
MUD	multi-unit dwelling
MY	model year
NA	naturally aspirated
NADA	National Automobile Dealers Association
NHTS	National Household Travel Survey
NHTSA	National Highway Traffic Safety Administration
NHTSA Base Engine Map	IAV Gasoline Engine1 Map as described at Draft TAR, p. 5-505
NRC	National Research Council
NVES	Strategic Vision's New Vehicle Experience Survey
NVH	noise-vibration-harshness
NPRM	notice of proposed rulemaking
NREL	National Renewable Energy Laboratory
OBD	on-board diagnostics
OEM	original equipment manufacturer
OLV	overlap volume
OMEGA	EPA's Optimization Model for reducing Emissions of Greenhouse gases for Automobiles

ONP	One National Program
ORNL	Oak Ridge National Laboratory
PEV	plug-in electric vehicle
PFI	port fuel injection
PHEV	plug-in hybrid electric vehicle
PM	particulate matter
R&D	research and development
REEV	range-extended electric vehicle
RIA	regulatory impact analysis
RON	research octane number
RPM	revolutions per minute
RWD	rear wheel drive
SAE	Society of Automotive Engineers
SLOOS	U.S. Federal Reserve Senior Loan Officer Opinion Survey
SOHC	single overhead cam
U.S.	United States (of America)
USCAR	United States Council for Automotive Research
variable CS valve	variable crankcase suction valve
VMT	vehicle miles travelled; also referred to as vehicle lifetime miles (VLM)
Volpe Model	CAFE Compliance and Effects Modeling System
V2G	vehicle to grid
V2V	vehicle to vehicle
VGI	vehicle to grid interface
VVL	variable valve lift
VVT	variable valve timing
W	watts
ZEV	zero emission vehicle
ZEV Mandate	13 CCR §§ 1962.1, 1962.2
ZEV Program	13 CCR §§ 1962.1, 1962.2

Attachments

Attachment1_Novation_Fleet_Level_Tech_Study

Attachement2_Novation_Vehicle_Level_Tech_Study

Attachment3_CAR_Powertrain_Study

Attachment4_CAR_Mass_Reduction_Study

Attachment5_Novation_Analytics_Briefing_May_2016

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Introduction

In 2011, 13 light-duty vehicle manufacturers, including several Alliance members, submitted letters[2] to the U.S. Environmental Protection Agency (EPA) and National Highway Traffic Safety Administration (NHTSA) (collectively, Agencies) in support of the model year (MY) 2017-2025 ONP. A key reason those manufacturers were able to support standards[3] that would not be in effect until over a decade later was due to the Agencies' agreement to conduct a midterm evaluation (MTE) of those standards. The MTE is meant to reassess the practicability and feasibility of the MY2022-2025 standards by examining all relevant factors, including the availability, benefits, and costs of technology; factors related to customer acceptance; economic factors; and other related issues.[4] A proposed determination of the appropriateness of the GHG standards and notice of prosed rulemaking (NPRM) for the CAFE standards for MY2022-2025 is expected in 2017[5] and a final determination on the GHG standards must be made by April 2018, with a CAFE final rule to follow.[6] The Draft TAR is the first milestone in the MTE process. It forms the basis on which the proposed determination and NPRM will rely. As such, it is critically important that it be fact-based, accurate, and robust in its analysis.

The Draft TAR contains more than 1,200 pages and incorporates the findings of dozens of separate studies, most of which were not previously available. Recognizing the complexity of this analysis, on August 1, 2016, the Alliance submitted a request for an extension of the 60-day comment period.[7] The Agencies denied this request. Nonetheless, the 60-day comment period is not a sufficient amount of time to review and provide meaningful input on all of the complex technical analyses in the Draft TAR. The Alliance anticipates submitting supplemental comments after the close of the 60-day comment period, and expects that the Agencies will respond formally to those comments prior to issuing a proposed decision and NPRM to ensure that they include the most up-to-date information.[8]

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[2] "Transportation and Climate: Presidential Announcements and Stakeholder Commitment Letters." EPA. Accessed September 7, 2016. https://www3.epa.gov/otaq/climate/letters.htm#2011al.
[3] The Alliance recognizes that the MY2022-2025 CAFE standards are considered "augural" and subject to a de novo rulemaking. For simplicity, these standards are herein referred to, at times, without noting their augural status.
[4] 40 CFR 86.1818-12(h) and 77 Fed. Reg. 62784 (Oct. 15, 2012).
[5] See https://www3.epa.gov/otaq/climate/mte.htm and http://www.nhtsa.gov/Laws+&+Regulations/CAFE+-+Fuel+Economy/ld-cafe-midterm-evaluation-2022-25. Accessed September 23, 2016)
[6] *Id.*
[7] Letter from Chris Nevers, Vice President, Environmental Affairs, The Alliance of Automobile Manufacturers to Chris Lieske, Environmental Protectio Agency, Rebecca Yoon, National Highway Traffic and Safety Administration, and Michael McCarthy, California Air Resources Board (August 1, 2016). Docket ID EPA-HQ-OAR-2015-0827-0928 and NHTSA-2016-0068-0022.
[8] Letter from Julia Rege, Director, Environment and Energy, The Association of Global Automakers, Inc., and Chris Nevers, Vice President, Environmental Affairs, The Alliance of Automobile Manufacturers to Janet McCabe, Acting Assistant Administrator for the Office of Air and Radiation, US Environmental Protection Agency and Paul

The Alliance has significant concerns with much of the data and analyses in the Draft TAR. Our key concerns fall into two areas. The first is a fundamental disagreement with the level of technologies modeled by the Agencies as likely required for manufacturers to comply with the future standards. Simply stated, there are numerous flaws in the modeling, and additional (and more costly) technology will be needed than suggested by the Draft TAR. The second concern is that the Agencies have not adequately met their obligation to assess customer acceptance of those technologies that will be necessary for future compliance. These concerns are interrelated: if flawed modeling projects the cost of compliance incorrectly low, then customer acceptance, willingness, and/or ability to pay for such efficiency improvements will be lower than projected. In particular, customer willingness to pay for efficiency is further hampered by the dramatic decrease in fuel prices since the 2012 final rulemaking (2012 FRM).[9] This directly threatens both the ability of manufacturers to comply with the standards and the overall success of the program.

In addition, experience with the ONP has demonstrated two other concerns, implicit in the Draft TAR, which must be addressed. First, "one" national program has not resulted in harmonizing the three underlying programs of EPA, NHTSA and the California Air Resources Board (CARB). Second, flexibilities and other necessary regulatory elements are crucial to compliance and the success of the program.

The following comments and ten appendices address these concerns, and a number of other issues.

Agency Modeling Underestimates Actual Technologies Required

To predict GHG and CAFE compliance (and associated costs) five to eight model years in the future, the Agencies use various modeling techniques to identify potentially available technologies and to assess their effectiveness, cost, and impacts across the entire light-duty vehicle fleet. The Alliance has identified numerous issues with these techniques that must be addressed before going forward with the proposed determination and NPRM. In essence, the Agencies' fleet level modeling results do not match independent analyses of the technologies which will be required to meet future GHG and CAFE targets. These analyses predict more electrification will be required (including full hybrids) than either Agency predicts. There are several reasons for the differences in modeling outputs, including the Agencies' overestimation of technology effectiveness.

Hemmersbaugh, Chief Counsel, National Highway Traffic Safety Administration (Sept. 9, 2016). Docket ID EPA-HQ-OAR-2015-0827-3292.

[9] "2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards," 77 Fed. Reg. 62623 at 62624 (Oct. 15, 2012).

Specific comments on the Agencies' vehicle technology package simulation modeling can be found in Appendix A, and comments on specific vehicle technologies in Appendix B. These appendices address the overarching concern that the Agencies appear to have minimized real-world constraints and have selected only the most optimistic data available for the purposes of evaluating technology costs, effectiveness, and leadtime.

Agency Modeling Outputs Do Not Match Third-Party Analyses

Third-party modeling outputs, both at the vehicle and fleet level, do not match either Agency's projections. The resulting conclusion from these third-party studies is that more technology will be needed than projected in the 2012 FRM. The Agencies' modeling methods overestimate the effectiveness of technologies at the vehicle level and over-project the vehicle level benefits to the fleet.

The Alliance consulted Novation Analytics (who also provided the Vehicle Load Reduction analyses attached as Appendix A to the Draft TAR) for their assessment of the Agencies' 2012 FRM technology pathway modeling. Novation Analytics provided a study[10] (Fleet Level Tech Study, attached as Attachment 1) which includes today's fleet with the latest, most advanced fuel efficient technologies noted by the Agencies as effective through 2025. This study examined the feasibility of achieving the energy conversion efficiencies implied by the MY2021 and MY2025 GHG and CAFE targets using the Agencies' projected technology mix.[11] The results of the study, shared with the Agencies and CARB, show that the MY2021 and MY2025 targets cannot be met with the suite of technologies at the deployment rates projected by the Agencies in the 2012 FRM. It concludes that more technology will be needed than predicted by the Agencies. Essentially, only vehicles as efficient as modern strong hybrids will meet those future targets and "conventional" powertrains will likely not displace the need for more electrification.

Oak Ridge National Laboratory (ORNL) reached similar conclusions in a recent publication.[12] ORNL concluded that "[t]he path to meeting 2025 standards will likely involve significantly larger numbers of hybrid electric powertrain vehicles and/or plug-in vehicles being sold, compared to the current U.S. sales of such vehicles." and "[i]t will be quite difficult for the most efficient gasoline vehicles to reach 29%-31% combined-cycle efficiency, but this is the level the gasoline fleet would need to average to comply with the 2025 regulations…"

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[10] "Technology Effectiveness – Phase 1: Fleet-Level Assessment." Novation Analytics. 2015.
[11] The Fleet Level Technology Study assumed all agency-projected mass, aerodynamic, and tire load reductions. It also accounted for learning and agency assumptions of credits.
[12] Thomas, J., "Vehicle Efficiency and Tractive Work: Rate of Change for the Past Decade and Accelerated Progress Required for U.S. Fuel Economy and CO_2 Regulations," *SAE Int. J. Fuels Lubr.* 9(1):2016, doi:10.4271/2016-01-0909.

Novation Analytics was subsequently consulted to investigate potential vehicle level sources of the issues identified in the Fleet Level Tech Study. The resulting study on vehicle level technologies (Vehicle Level Tech Study, attached as Attachment 2) identified Agency modeling process issues as the key source of error in technology benefit estimates.[13] This study identified a number of issues with the Agencies' modeling processes including:[14]

1. Some of the full vehicle simulation results used to calibrate technology effectiveness models are over-optimistic and fail basic, and very liberal, plausibility checks… the model assumptions do not properly account for implementation issues such as durability and reliability requirements, emissions and on-board diagnostics (OBD) compliance, and consumer needs such as drivability and noise-vibration-harshness (NVH) limits.
2. The [EPA Lumped Parameter Model] used to project the incremental effectiveness of technologies (applied to each manufacturer's vehicle models) are not based on the fundamental factors determining vehicle CO_2 and fuel consumption and thus fail to adequately capture the efficiency trends and relationships which influence the incremental benefit of added technology.
3. The [A]gencies' modeling processes do not recognize the inherent variability of efficiency within the light-duty fleet, treating all products within a category as equal… this approach results in over-projection of the most efficient vehicles.
4. No procedure or methodology is currently in place to check the outcomes of the technology effectiveness projection process against logical efficiency metrics and limits. Without such checks, the outcomes can exceed plausible limits.
5. **The combination of these sources of error – overoptimistic vehicle simulation results used to calibrate an oversimplified technology effectiveness projection process —compound and yield overoptimistic vehicle-level and ultimately fleet-level results.** (Emphasis added.)

In summary, the Vehicle Level Tech Study shows that the Agencies' modeling processes, particularly the EPA's Lumped Parameter Model (LPM), have systemic issues that need to be corrected to obtain accurate results.

To better ascertain fleet plausibility in MY2022-2025, the Agencies should move to full vehicle simulation with quality and plausibility checks. If EPA retains the LPM, it should be updated to reflect proper powertrain principles and its outputs should be validated against actual vehicles and full vehicle simulations which were not used to calibrate the LPM.

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[13] "Technology Effectiveness – Phase II: Vehicle-Level Assessment." Novation Analytics. 2016.
[14] *Id.* at 8 et seq.

The 60-day comment period was not enough time to make a thorough analysis of all the modeling and to engage the Agencies in the sustained manner needed to resolve all the modeling issues before submitting our comments on the Draft TAR. The Alliance looks forward to working with the Agencies to address these and other modeling issues. We believe that the Agencies could hold public workshops to reassess and remedy the findings and recommendations identified in the Draft TAR and specifically in Chapter 5. The workshops could emphasize resolving issues in an iterative manner together with automakers and other experts, adding workshop days as needed, instead of the format using a presentation followed by questions and answers.

Technology Effectiveness and Cost

The core of the Agencies' technology assessments are the analyses located in Chapter 5 of the Draft TAR. The Alliance provides comments in Appendix B on some of the key technologies modeled by the Agencies such as advanced Atkinson cycle engines, gasoline downsized turbocharged direct injection (GTDI) engines, transmission technologies, mild hybrids, P2 versus power split hybrids, mass reduction, aerodynamic improvement, and tire rolling resistance reduction. Due to the limited time made available to comment on the Draft TAR, the Alliance focused its efforts on what were considered key technologies, but notes that the Agencies should not interpret a lack of comment on any specific area as assent.

The analysis includes the following key findings:

1. Advanced Atkinson Cycle Engines: EPA combines an Atkinson cycle engine (based on the Mazda SkyActiv engine) with cooled exhaust gas recirculation (CEGR) and cylinder deactivation, claiming large synergistic benefits, and applies the technology to 40% of the modeled MY2025 fleet. The Alliance identified multiple technical errors resulting in over-optimistic projections of benefit. In addition, we note that Mazda, other automakers, and EPA have not been able to verify the modeled benefits because this technology package could not be fully operated, even in a laboratory setting.
2. Downsized GTDI Engines: The Agencies' model inputs were based on high octane fuel and no consideration was given to customer acceptance when determining the degree of downsizing.
3. Transmission Technologies: The effectiveness modeled by the Agencies exceeds that demonstrated by manufacturers using the technologies described. Furthermore, EPA's grouping of transmission technologies ignores the unique effectiveness and cost implications of these vastly different technologies.
4. Mild Hybrids: The Agencies' cost and benefits estimates are inconsistent and should be revisited. In addition, projected costs failed to include those associated with vehicle integration.

5. Strong Hybrids: The Draft TAR assigns identical cost and effectiveness values to both Power-Split and P2 hybrids. The architectures of these two technologies are sufficiently different to warrant separate assessments.
6. Mass Reduction: Modeling of mass reduction in a continuous fashion instead of discrete bins yields incorrect benefit assumptions. Theoretical mass reductions do not properly account for materials already in use.
7. Aerodynamic Improvements: Aerodynamic improvements are too broadly applied, resulting in implausible levels of aerodynamic reduction for many vehicles.
8. Tire Rolling Resistance: Further consideration must be given to the degree of rolling resistance reduction applied to specific vehicles.

Individually and collectively, these issues will result in overestimation of the benefits of the technologies modeled, and subsequently result in underestimating the overall penetrations of technology to meet the MY2022-2025 standards (and resulting costs).

The Alliance makes the following recommendations to improve Chapter 5:

1. Full vehicle simulation modeling should be used to assess CO_2 and fuel economy (FE) performance. That is, the Lumped Parameter Model should be retired.
2. The advanced Atkinson technology package with CEGR and cylinder deactivation should not be utilized in the MTE analysis until the technology can be demonstrated to operate across all modeled operating points.
3. The Agencies should incorporate and make readily available modeling quality control parameters.
4. The GTDI packages should be revaluated for high load operation and other constraints while operating on 91 research octane number (RON) market and certification test fuels.
5. Vehicle performance metrics should be harmonized across both Agencies.
6. The EPA high efficiency transmission gear box (HEG2) package should not be utilized in modeling until it can be demonstrated as feasible.
7. The Agencies should study appropriate limits for reductions in tire rolling resistance related to customer acceptance.
8. Due to the various issues manufacturers face with implementing CEGR and cylinder deactivation, both Agencies should further explain and document the assumptions used in simulating related loss and electrical load functions.
9. The negative fuel economy and CO_2 impacts associated with Tier 3 emissions should be included in the analysis.
10. The negative fuel economy and CO_2 impacts associated with the California 1 milligram-per-mile particulate matter standard should be taken into account.
11. The Agencies should harmonize vehicle electrical loads.

Due to time constraints, the Alliance did not assess the fleet level costs of compliance described in the Draft TAR (or underlying assumptions such as learning and indirect costs), but did sponsor studies by the Center for Automotive Research (CAR) to assess the cost and effectiveness of powertrain technologies and the costs and challenges to reducing mass.

The CAR Powertrain Study (attached as Attachment 3),[15] gathered actual cost data for powertrain technologies and pathways directly from manufacturers. The manufacturers' aggregated average direct manufacturing costs (DMC), when compared to NHTSA's cost estimates, show that most DMCs are, in general, higher than NHTSA's costs from the 2012 FRM. Given the trend shown in the study, even neglecting the predicted need for more technology than the Agencies estimated, the Alliance expects the Agencies' under-estimation of technology costs have continued in the Draft TAR. The CAR Powertrain Study indicates the cost of compliance to the MY2022-2025 targets will be higher than the Agencies projected for two reasons: more technology is needed than projected; and, in general, manufacturer costs for most technologies are higher than estimated by the Agencies.

The CAR Mass Reduction Study (attached as Attachment 4)[16] gathered vehicle content information and mass reduction pathways from nine manufacturers and vehicles representing almost half of U.S. sales. Comparing the CAR work to the Draft TAR, some general conclusions can be made, including the need for the Agencies to reassess the cost of mass reduction. Based on the updated EDAG Engineering GmbH cost study,[17] the Alliance believes that the Agencies' final mass reduction cost curves should be updated, and likely increased, based on evolution of the baseline fleet, barriers to mass reduction implementation, mass added to meet future market and regulatory requirements, and the manufacturers' challenges in fully applying secondary mass reductions."

Baseline Technology Assessment

Perhaps the most critical step in modeling the technologies (and costs) required to bring the future fleet into compliance with the MY2022-2025 standards is an accurate evaluation of the technologies already in use on current vehicles. This ensures that the projected future level of technology applied to meet the standards is feasible and practicable, and that the costs of such future technology are appropriately taken into account.

There are several issues in the Agencies' development of the baseline fleets that will result in significant errors and inconsistencies. For instance, the two Agencies use different baseline years (MY2014 for EPA and MY2015 for NHTSA). There are also errors in the baseline mass

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[15] "An Assessment of Powertrain Technology Costs Associated with Meeting CAFE and GHG Standards." Center for Automotive Research. 2016. Attached as Attachment3_CAR_Powertrain_Study.
[16] "Assessing the Fleet-wide Material Technology and Costs to Lightweight Vehicles." Center for Automotive Research. 2016. Attached as Attachment4_CAR_Mass_Reduction_Study.
[17] Singh, H., Kan, C-D., Marzougui, D., & Quong, S. (2016, February). "Update to future midsize lightweight vehicle findings in response to manufacturer review and IIHS small-overlap testing" (Report No. DOT HS 812 237). Washington, DC: National Highway Traffic Safety Administration.

reduction, including the degree of technology already implemented, and a failure to apply the analysis to individual vehicles. In addition, there are major problems in the baseline aerodynamic drag assessment. A number of smaller problems also exist in the analysis, including assumptions about baseline tire rolling resistance. All of these issues and other baseline-related matters are extensively discussed in Appendix C.

Customer Acceptance Concerns

There is no question that manufacturers are capable of developing and producing products that meet the MY2022-2025 standards. However, the success of the program depends on customer purchase of those products, not the mere ability to produce them. The Draft TAR projects far less technology, particularly less electrification, than will be necessary, and hence the Agencies posit less cost than will be necessary. This error has a direct influence on the analysis of customers' ability (and willingness) to purchase new vehicles.

Although customers value fuel economy, they consider a wide range of other factors when making new vehicle purchasing decisions. Among these are cost, affordability, comfort with new technology, seating capacity, handling, tow and load capability, safety, and comfort. Rather than asking whether the auto industry can build a vehicle that achieves MY2025 compliance, the Agencies should be asking whether the auto industry will be able to sell a fleet of vehicles that meet these future targets.

In the 2012 FRM, the Agencies indicated that an analysis of customer acceptance would be vital to the assessment of whether the MY2022-2025 standards are appropriate. Notwithstanding the central importance of this issue, under 30 pages of the 1,200-page Draft TAR are dedicated to an evaluation of customer acceptance. After providing a cursory literature review, the Agencies conclude that they cannot make any significant conclusions. They point to positive statements from professional auto reviewers without even attempting to link such statements to actual purchasing behaviors. The Alliance respectfully submits that this topic requires more extensive and robust study than a review of enthusiast or consumer magazines.

Indeed, other organizations have recognized the need for serious research on customer acceptance. For instance, the National Research Council's 2015 report on fuel economy technologies for light-duty vehicles[18] contains three separate recommendations for further research by the Agencies, including "research on the existence and extent of the energy paradox

[18] "Cost, Effectiveness and Deployment of Fuel Economy Technologies for Light-Duty Vehicles." National Academy of Sciences, National Research Council to the National Academies. 2015.

in fuel economy, the reasons for customers' undervaluation of fuel economy relative to its discounted present value, and differences in customers' perceptions across the population."[19]

It is no answer to this lack of serious research to assert that manufacturers have had a history of over-compliance with the standards for the early model years. While 22% of MY2015 vehicles operating on diesel or gasoline meet the MY2018 standards or can do so with air conditioning improvements, fewer than 4% of current vehicles can meet the MY2022 targets, and no diesel or non-hybrid gasoline models meet the MY2025 target. While the Agencies contend that these out-year standards do not require significant hybridization or electrification, this conclusion exceeds current technology realities.

The Fleet Level Tech Study[20] further illustrates this disconnect. Novation Analytics found that automakers will need to apply additional and costlier technologies than were initially predicted to meet the projected MY2021 and MY2025 targets, and that the post-MY2021 standards cannot be achieved without significantly higher sales of advanced technology vehicles, including hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), and battery electric vehicles (BEVs) (also known collectively plug-in electric vehicles or PEVs). Novation Analytics concludes, "[m]oving the entire industry to the current best spark-ignition powertrains would provide compliance only to MY 2020. Advanced [spark ignition] SI technologies, unproven in production, and/or high rates of electrification will be required by MY 2025."[21]

Hybridization and electrification raise costs and, to date, customers have not demonstrated a willingness to purchase such vehicles in large numbers. One reason is the current low state of gasoline prices. The 2012 FRM was developed with an expectation of structurally high gas prices but is unfolding in a period of sustained low gas prices, profoundly impacting customer choice. In the Agencies' original analysis of the 2017-2025 joint rule, they predicted gas prices would be $3.87 in 2010 dollars by 2025, or about $5 a gallon. This assumption was made when fuel prices were at their highest level in the past 40 years, exceeding those of the late 1970s and early 1980s.[22] The fuel market has shifted quite dramatically since the 2012 FRM. Earlier this month, the American Automobile Association (AAA) national average fuel price was $2.22 and in August, gas prices in 14 states were below $2.00 per gallon.[23] While various uncertainties have the potential to disrupt the world oil market, in its *2015 Annual Energy Outlook*, the U.S. Energy Information Adminsitration (EIA) projects gas prices to remain relatively low through

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[19] *Id.*, pp. 333-334.
[20] "Technology Effectiveness – Phase 1: Fleet-Level Assessment." Novation Analytics. 2015.
[21] "Trade Association Studies; Powertrain Technology Effectiveness, Phase II." Novation Analytics. Technical Briefing. May 17, 2016. Accessed September 21, 2016. Attached as Attachment 5.
[22] "Short-Term Energy Outlook." U.S. Energy Information Administration. Accessed September 21, 2016. http://www.eia.gov/forecasts/steo/realprices/.
[23] "AAA Gas Prices." American Automobile Association. Accessed September 21, 2016. http://gasprices.aaa.com/.

2030.[24] Such low gas prices have resulted in a disconnect between customer preferences and the future CAFE/GHG standards. The 2012 FRM projected the 2025 vehicle fleet to be comprised of 67% passenger cars and 33% trucks. However, the Agencies' updated assessment in the Draft TAR now projects that the fleet mix in 2025 will likely be 52% cars and 48% trucks–acknowledging the direct impact low gas prices have on the composition of the vehicle. When gas prices fall, especially in the context of improving mileage across segments of the market, the desire to walk out of the showroom with a hybrid (or other alternative powertrain) diminishes.

The customer acceptance challenges of meeting the MY2022-2025 standards are real and need more sophisticated analysis in the final TAR and upcoming NPRM. To perform an appropriate cost-benefit analysis, the Agencies must address the matters discussed above as well as the following issues (each of which is discussed in greater detail in Appendix E):

- The enormous disparity between the payback periods anticipated by the Agencies and those that customers will tolerate raises important questions regarding long-term viability of the new car market.
- Automakers have limited tools with which to drive customer acceptance despite significant efforts to promote and incentivize highly efficient vehicles.
- Growth in the sales of highly efficient vehicles has been limited by low gasoline prices, the satisfaction customers already express with current fuel economy levels via modern internal combustion engines, and the fact that fuel economy savings are reduced as miles-per-gallon increase.
- Positive third-party reviews often do not translate to higher sales, particularly for electric powertrain vehicles.
- Increasing costs have an effect on affordability, and this issue needs further analysis, especially if the current, low-interest financing era ends.
- Cost increases resulting from a steep increase in fuel-efficiency requirements are likely to reduce the overall demand for new vehicles and constrain employment throughout the automotive sector.

Because of the importance of customer acceptance, the Alliance has done an extensive analysis of the matter, concluding that compliance with the MY2022-2025 standards will require a much higher and earlier deployment of more expensive technologies, with far higher levels of electrification than suggested in the Draft TAR. As a result, those levels and costs are far higher than customers are currently prepared to accept (See Appendix E).

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[24] "Annual Energy Outlook 2015." U.S. Energy Information Administration. Accessed September 21, 2016. https://www.eia.gov/forecasts/archive/aeo15/.

Harmonization Issues

NHTSA and EPA Harmonization

On June 20, 2016, the Alliance and The Association of Global Automakers, Inc. (Global Automakers)[25] submitted a petition[26] (see Attachment 6) asking EPA and NHTSA to make several regulatory changes to better harmonize their respective regulations for GHGs and fuel economy. The issues raised in this petition are relevant for the MTE because of their many interactions with the assessments of the MTE. In addition, there are other differences between the EPA, NHTSA and CARB programs subsumed in the ONP. First, there is an inconsistency in the technical assessments performed by EPA and NHTSA. Second, and more significantly, the Draft TAR completely fails to harmonize with CARB's Zero Emission Vehicle (ZEV) Program ("ZEV Program" or "ZEV mandate")[27] by ignoring the costs of the ZEV mandate.

The Draft TAR Fails to Account for Costs and Technologies Needed to Comply with the ZEV Mandate

For the first time, EPA has included the estimated volumes of plug-in electrified and fuel cell vehicles that automakers are expected to produce under theZEV mandate. The ZEV mandate, as adopted by California and nine other states, will effectively force specific GHG reducing solutions (heavy electrification) into the market rather than allowing the "technology-agnostic" approach previously advocated by EPA and NHTSA. Because EPA waived the ZEV Program under the Clean Air Act, it is now wholly appropriate that EPA include the effect of the ZEV mandate when projecting technology pathways and costs for EPA's own national GHG program.

California's ZEV Mandate creates $6 billion in costs

When calculating the costs of the GHG program, EPA builds into its reference fleet the benefits of 280,300 fully electric, plug-in and hydrogen fuel-cell vehicles that manufacturers are expected to produce in response to the ZEV Program. However, EPA does not take into account the cost of the ZEV Program in California and the other ZEV states – regions of the country which also fall under the requirements of the federal GHG and FE standards. Economists working for CARB estimate that vehicles produced in response to the ZEV mandate will cost customers between $7,500 and $15,000 more in MY2025 as compared to today's average vehicle prices.[28]

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[25] Global Automakers' members are Aston Martin, Ferrari, Honda, Hyundai, Isuzu, Kia, Maserati, McLaren, Nissan, Subaru, Suzuki, and Toyota. Please visit www.globalautomakers.org for further information.
[26] Letter from C. Nevers to Mark Rosekind, PhD and Gina McCarthy re: 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).
[27] 13 CCR §§ 1962.1 and 1962.2
[28] "Staff Report: Initial Statement Of Reasons, Advanced Clean Cars, 2012 Proposed Amendments To The California Zero Emission Vehicle Program Regulations." California Environmental Protection Agency, Air

They also estimate that by MY2025, compliance with the ZEV Program in California alone will cost automobile manufacturers more than $6 billion annually.[29]

EPA's failure to consider the costs of the ZEV mandate would conflict with its own guidance and could result in arbitrary decision-making, for several reasons. First and fundamentally, the integrity of cost-benefit analysis requires making equivalent assumptions on both the cost and benefit sides of the analysis. Specifically, if the EPA assesses the *benefits* that the ZEV mandate will contribute to achieving the MY2022-2025 standards, the *costs* of that mandate should also be considered. Otherwise, the cost assessment will understate the true costs to manufacturers for achieving the future standards. This is particularly important where the costs of the ZEV mandate are large enough to effectively dictate a particular pathway for achieving compliance at costs that can materially affect the feasibility of achieving the CAFE and GHG standards. Alternatively, were the Agencies to disregard the costs of the ZEV mandate, the costs of compliance with the MY2022-2025 standards should be spread over only the incremental benefits of emissions reductions *beyond* the ZEV mandate. Still this would be a less useful approach, since accounting for all of the costs and benefits better positions the Agencies to consider the feasibility of the standards.

Second, EPA has explained in its guidance the position that it is generally appropriate to include existing regulations in the cost baseline because, presumably, those costs have been accounted for elsewhere and should not be counted twice.[30] However, EPA has not considered the cost of the ZEV program at any point in time.[31] Indeed, CARB has not considered the full costs of

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Resources Board. 2011. 64. Accessed September 21, 2016.
https://www.arb.ca.gov/regact/2012/zev2012/zevisor.pdf.

[29] "Staff Report: Initial Statement Of Reasons, Advanced Clean Cars, 2012 Proposed Amendments To The California Zero Emission Vehicle Program Regulations." California Environmental Protection Agency, Air Resources Board. 2011. Table 5.6. Accessed September 21, 2016.
https://www.arb.ca.gov/regact/2012/zev2012/zevisor.pdf.

[30] See National Center for Environmental Economics, Office of Policy, U.S. Environmental Protection Agency, "Guidelines for Preparing Economic Analyses" (December 17, 2010) at 5-9. Cited authority states "[i]f a proposed regulation is expected to increase compliance with a previous rule, the correct measure of the costs and benefits generally excludes impacts associated with the increased compliance. This is because the costs and benefits of the previous rule were presumably estimated in the economic analysis for that rule, and should not be counted again for the proposed rule."

[31] In evaluating whether to grant California the waiver necessary to implement the ZEV mandate, EPA did not fully evaluate the costs of the mandate at that time, either. Instead, EPA largely deferred to CARB estimates. See, e.g., U.S. Environmental Protection Agency, "Notice of Decision Granting a Waiver of Clean Air Act Preemption for California's Advanced Clean Car Program and a Within the Scope Confirmation for California's Zero Emission Vehicle Amendments for 2017 and Earlier Model Years," 78 Fed. Reg. 2111, 2115 (Jan. 9, 2013), noting that in the waiver context, EPA gives "very substantial deference to California's judgment" on the balancing of costs and benefits, and 78 Fed. Reg. 2118, noting that in decision whether to grant a waiver, EPA "provide[s] California with the broadest possible discretion in setting regulations that it finds protective of the public health and welfare while limiting EPA's review to a narrow role that provides substantial deference to the State."

compliance with the ZEV mandate, including the other states that have adopted the ZEV mandate. Omitting the costs of measures that would play a substantial role in achieving compliance with the MY2022-2025 standards would thus run counter to the objectives of transparency and sound decision-making that underlie the Agencies' cost-benefit analysis.

In summary, the Alliance believes that EPA should include the cost of the ZEV Program in the TAR, especially since the ZEV mandate provides no net GHG benefit and could force a more expensive compliance pathway than might otherwise be taken.

The Alliance also notes that NHTSA does not build ZEV compliance into its baseline scenario. A sensitivity analysis of EPA modeling that includes NHTSA's assumptions in this regard is critical for a realistic assessment of costs and benefits of the GHG program. For further discussion of these matters, see Appendix H.

NHTSA and EPA Performed Separate Technical Assessments

EPA and NHTSA have conducted separate technical assessments that the Agencies then combined into a single Draft TAR. In the Draft TAR's executive summary, the Agencies conclude that their "independent analyses complement one another and reach similar conclusions."[32] Considering their different statutory mandates, different approaches to defining baselines, and variations between the models used, some variation in outcomes is, of course, to be somewhat expected. However, the breadth of disagreement between the Agencies on several key modeling outcomes leads one to ask whether these outcomes really do "complement one another." For example, the percentage of higher compression ratio, naturally aspirated gasoline engines automakers are expected to deploy to meet the MY2025 standards differs by 43%. Similarly, the percent of turbocharged and downsized gasoline engines differs by 21%, and the percent of stop-start technology differs by 18%.[33] While some of these disparities are explainable, the delta between the Agencies' modeling outcomes implies that they are actually in significant *disagreement* as to how automobile manufacturers could comply with the standards, leading one to question their joint conclusions.

Regulatory Elements Necessary for Compliance

The Alliance's member companies remain committed to pursuing all technologies that have quantifiable GHG emissions and FE improvements both on-cycle and off-cycle. All stakeholders

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[32] 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, (EPA-420-D-16-900, July 2016) at ES-2.
[33] 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, (EPA-420-D-16-900, July 2016), at ES-10, Table ES-3.

have acknowledged the contribution of these technologies to the environmental goals of the ONP with their inclusion in the regulation. The automakers' primary regulatory need is a renewed focus on removing all obstacles that are having the unintended result of slowing investment and implementation of these technologies. Agency action is needed to ensure that a simplified credit application process is quickly administered, including the establishment of processes for new technologies as they emerge. The Agencies should also reconsider the limits placed on recognizing the environmental impact of mobile air conditioning (MAC) improvements.

The Alliance proposes cooperating with the Agencies to develop technical studies needed to quantify the benefits of the next generations of innovative fuel savings technologies associated with safety and congestion mitigation from improved vehicle-to-vehicle and vehicle-to-grid communication, to car-sharing and car-hailing services. The Agencies should develop off-cycle credit frameworks to accelerate their implementation prior to MY2026. This includes addressing concerns with the AC17 test[34] used to quantify MAC system improvements. Actions to address the above will encourage, not slow, the introduction of technology.

Further details on the recommendations below are set forth in Appendix G.

Electric Vehicle Upstream Emissions and Incentives

All of the Draft TAR scenarios assume zero grams CO_2 per mile for the upstream emissions associated with generating electricity used as a transportation fuel. Complicating a shift towards electrification is the requirement in the regulation that holds automakers responsible for CO_2 from electricity generation at utility power plants. Automakers are already concerned about customer acceptance of electrified products in the market. This requirement further disincentivizes electrified vehicles from the regulatory perspective, degrading the CO_2 performance of plug-in hybrids to be similar to hybrid electric vehicles. This disincentive also works directly against the CARB ZEV mandate. Since the upstream utility emissions are being regulated by EPA and the states, they should not be assigned to automakers (none of which have control over their generation). The Alliance also recommends that the EPA extend the advanced technology vehicle multiplier through MY2025 to continue the promotion of electric, plug-in hybrid, and fuel cell vehicles.

Other Issues Discussed

Employment Impacts

The MY2017-2025 regulations specifically required the MTE to assess the employment impacts of the proposed standards. The Draft TAR chapter on employment consisted of exactly 14 pages

[34] 40 CFR § 1066.845

out of the 1,217-page Draft TAR. In the end, the Agencies concluded, "[b]ecause we do not have quantitative estimates of the output effect, and only a partial estimate of the substitution effect, we cannot reach a quantitative estimate of the overall employment effects of the standards on auto sector employment or even whether the total effect will be positive or negative."[35] The Alliance believes that more study, preferably including quantitative estimates as discussed in Appendix F, is needed to determine the employment impacts of the MY2022-2025 targets before a proposed determination or NPRM can be issued.

In addition to the major concerns summarized above, the attachments to this document cover a number of other issues:

- Agency cost optimization modeling (Appendix D)
- Alternative fuel infrastructure (Appendix I)
- Safety analysis (Appendix J)
- Miscellaneous issues (Appendix K)

Conclusion

The Alliance appreciates the analysis completed thus far by the Agencies for the Draft TAR, but has serious concerns with the analysis. Although on the surface the Draft TAR appears to be robust, multiple technical errors have combined to generate an implausible assessment of the technologies needed and the associated costs required for compliance through MY2025. In addition, the almost complete lack of assessment regarding consumer acceptance and other downstream impacts, with so little time remaining to correct these issues before the next steps of the midterm evaluation, is highly concerning and needs to be addressed. The Alliance expects to develop further input on the Draft TAR, and will submit that input as supplements to these comments. Given all the questions that now remain unanswered regarding the MTE but that must be addressed before April 2018, the Alliance and its member companies look forward to closer engagement with the Agencies prior to the next step of the process. In particular, we look forward to working with the Agencies' to address all of the factors that need to be considered per the 2012 FRM and the Energy Policy and Conservation Act[36] that have not been adequately addressed in the Draft TAR, to ensure a complete and accurate MTE.

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[35] 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, (EPA-420-D-16-900, July 2016), at 7-14.
[36] 49 U.S.C.A Section 329029(f)

Appendix A: Vehicle Level Technology Package Simulation Tools (ALPHA, AUTONOMIE, LPM)

Introduction

It is generally well known that because many GHG and fuel consumption reducing technologies address the same efficiency loss mechanisms, the benefits of those technologies in combination are not equal to the sum of their individual benefits. Therefore, manufacturers, suppliers, U.S. national laboratories, and the Agencies have developed modeling tools which account for technology synergies and dis-synergies to estimate the benefits of technology packages at a vehicle level. In the context of the Draft TAR, these models include EPA's Advanced Light-Duty Powertrain and Hybrid Analysis (ALPHA) model and Lumped Parameter Model. NHTSA utilized Autonomie, and to a lesser extent, a table of vehicle technology synergies.

Both ALPHA and Autonomie are what are termed "full vehicle simulation models" by the National Academies of Science[37] or "one dimensional models" by Novation Analytics.[38] Regardless of the specific terminology used, the ALPHA and Autonomie models are vehicle-specific, physics-based, and are generally expected to provide more accurate simulations than regression models, *if the inputs are accurate*.

The LPM (referred to by Novation Analytics as a "zero dimensional (0-D) model)[39] is a linear regression model, calibrated to full vehicle simulations provided by Ricardo to inform the 2012 FRM[40] and by simulations from the ALPHA model. The LPM is not vehicle-specific (only requiring a user to select from one of six generic vehicle classes), is limited to predefined drive cycles, and is generally expected to be most accurate for only the specific vehicle configurations to which it is calibrated.

Together these models (plus the baseline technology assessment) form the basis of the technology package benefits used by the Optimization Model for reducing Emissions of Greenhouse gases from Automobiles (OMEGA)[41] and CAFE Compliance and Effects Modeling System (Volpe)[42] optimization models to select a mix of technology to theoretically meet the

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[37] "Cost, Effectiveness and Deployment of Fuel Economy Technologies for Light-Duty Vehicles." National Academy of Sciences, National Research Council to the National Academies. 2015. 292.
[38] "Technology Effectiveness – Phase II: Vehicle-Level Assessment." Novation Analytics. 2016. 14.
[39] *Id.* at 14.
[40] *Id.* at 15.
[41] Optimization Model for reducing Emissions of Greenhouse gases from Automobiles (OMEGA). Environmental Protection Agency. Accessed September 25, 2016. https://www3.epa.gov/otaq/climate/models.htm.
[42] CAFE Compliance and Effects Modeling System: The Volpe Model. National Highway Traffic and Safety Administration. Accessed September 25, 2016.

future standards. Given that Novation Analytics and Oak Ridge National Laboratory agree that the technology penetrations selected by the OMEGA and Volpe models in the 2012 FRM were insufficient for compliance in MY2022-2025,[43] and manufacturers have indicated that their own modeling efforts show that this is still the case for those projected in the Draft TAR,[44] an examination of these vehicle-level technology package simulation tools is warranted.

The Alliance's analysis, albeit constrained by the 60-day comment period, identified a number of issues:

1. The engine maps used by the full vehicle simulation models do not fully consider key technical issues, and are therefore generally optimistic.

2. The LPM is fundamentally flawed and needs to be replaced by full vehicle (physics-based) simulation modeling, or at minimum, significantly upgraded.

3. The Agencies need to enhance their plausibility and quality control checks. The 2012 FRM modeling results included a large number of implausible values which could have easily been identified if plausibility and quality control checks were in place.

4. The Agencies' modeling is premised on maintaining vehicle performance, but the performance metrics used are insufficient to ensure that this goal is met.

Detailed comments are provided below.

Comments on the ALPHA Model

Although discussed in several SAE papers published by EPA,[45] and at a vehicle modeling workshop in March 2016,[46] the full version of the ALPHA model used to inform the Draft TAR and specific supporting materials (such as the engine map inputs) were not made available for

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http://www.nhtsa.gov/Laws+&+Regulations/CAFE++Fuel+Economy/CAFE+Compliance+and+Effects+Modeling+System:+The+Volpe+Model.

[43] *See* "Agency Modeling Outputs Do Not Match Third-Party Analyses" in the summary.

[44] Manufacturers have indicated in general terms, and without revealing any particular product strategy, that they believe the Agencies' projections do not reflect the technology mix which will be required to meet the MY2022-2025 GHG and CAFE standards and that a greater degree of strong electrification will likely be required.

[45] *See* Advanced Light-Duty Powertrain and Hybrid Analysis (ALPHA) Tool. Environmental Protection Agency. Accessed September 25, 2016. https://www3.epa.gov/otaq/climate/alpha.htm.

[46] *See* NHTSA, EPA and CARB workshop on technology effectiveness modeling methodologies for the midterm evaluation draft technical assessment report (TAR) analysis for CAFE standards and GHG standards. National Highway Traffic Safety Administration. Accessed September 25, 2016. http://www.nhtsa.gov/Laws+&+Regulations/CAFE+-+Fuel+Economy/nhtsa-epa-carb-workshop-03012016.

public review until the Draft TAR was released. As such, the Alliance can only provide limited comment at this time, and may choose to comment further in the future.

The Alliance and its member companies welcome direct engagement with EPA's technical modeling staff to discuss ALPHA model inputs and operation. We believe that in the case of full vehicle simulation modeling, it is reasonable to believe automakers and regulators can come to agreement on the benefits of technology if both parties are open minded to the technical and regulatory constraints and potential future improvements.

As described more fully in Appendix B, the Alliance is concerned that engine maps and other underlying data in the ALPHA model have resulted in over-optimistic projections of technology effectiveness.

Comments on the Autonomie Model

Similar to issues identified in the ALPHA model, the Alliance has concerns with the engine maps developed for use in the Autonomie model in support of the Draft TAR.

The Alliance appreciates that NHTSA provided the detailed engine maps used to quantify the technology effectiveness for the Draft TAR in advance of its release. Engine maps used for Autonomie modeling to inform NHTSA's analysis were developed using Gamma Technology's GT Power tool.[47] Although we acknowledge use of GT Power simulation modeling as an accepted approach by the industry to evaluate new technologies, it has widely recognized limitations in its ability to predict knock and combustion stability, and to accurately reflect control limitations such as cam slew rates. The Alliance would appreciate the opportunity to work with NHTSA to discuss these and other inaccuracies in more detail.

The following sections detail the concerns with the IAV Automotive Engineering (IAV) engine maps developed for use in Autonomie to inform the Draft TAR.

Concerns with the IAV Gasoline Engine1 Map:

The Alliance has the following concerns with IAV Gasoline Engine1 Map[48] (NHTSA Base Engine Map). This map was compared to two similar production engines.

- For low- to medium-load and sub-1,000 revolutions-per-minute (RPM) conditions, the brake specific fuel consumption (BSFC) data was deemed optimistic for typical dual

[47] 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, (EPA-420-D-16-900, July 2016) at 5-462.
[48] *Id.* at 505, Figure 5.200.

overhead cam (DOHC) engines. The NHTSA Base Engine Map does not reflect cam control limitations that are typical of commercial calibrations.

- Low RPM torque and knock are aggressive for a port fuel injection (PFI) gasoline engine with 10.2 compression ratio (CR).
- The NHTSA Base Engine Map is also very aggressive at lower loads. This is evidenced by a comparison of industry benchmark data for an engine that has the benefit of additional technology such as variable valve lift (VVL) and higher compression ratio.

Figures A-1 and A-2 below capture the BSFC delta comparison with the key findings. Figure A-1 is a comparison to an original equipment manufacturer (OEM) benchmark 2.0L, four cylinder (cyl), naturally aspirated (NA), PFI, DOHC, dual cam variable valve timing (VVT), 10.2 CR engine. Figure A-2 is a comparison to a Honda Accord 2.4L, 4cyl, NA, gasoline direct injected (GDI), DOHC, VVT, 2-step VVL, 11.1 CR engine benchmarked by the United States Council for Automotive Research (USCAR). These comparisons illustrate the optimistic assumptions in the NHTSA Base Engine Map, as the efficiency of the NHTSA Base Engine Map is similar to a production engine with much more technology.

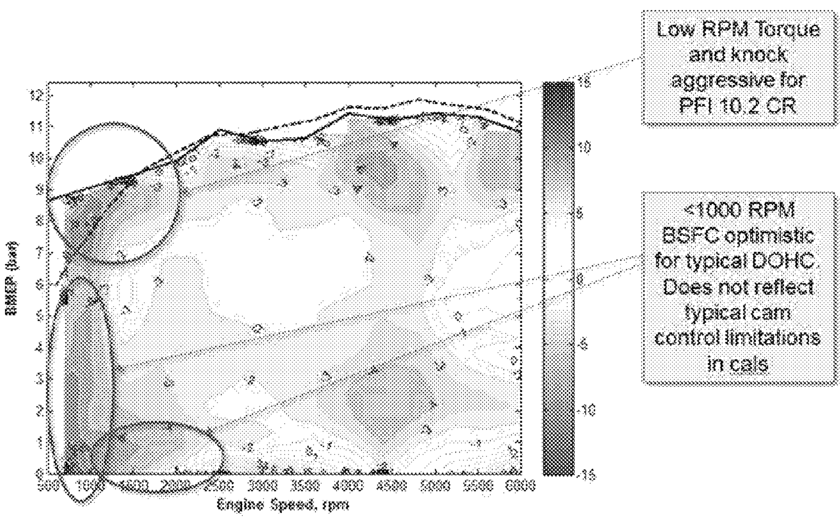

Figure A-1: Comparison of NHTSA Base Engine Map to similar OEM 2.0L Benchmark Engine

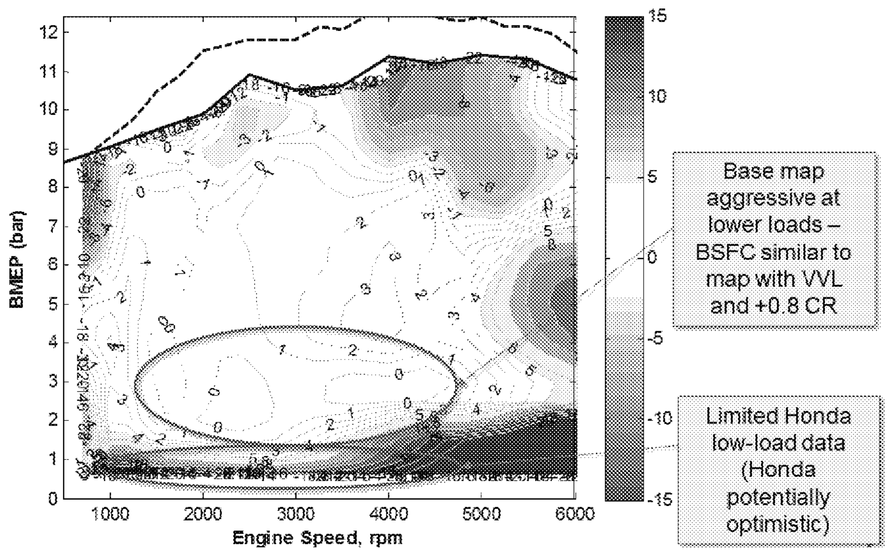

Figure A-2: Comparison of NHTSA Base Engine Map to Honda Accord 2.4L Engine

Concerns with the IAV Gasoline Engine2 Map

The following concerns are based on the analysis of the IAV Gasoline Engine2 Map,[49] which adds VVL to the NHTSA Base Engine Map:

- The increased torque and knock relief levels at low RPM are aggressive for just the addition of VVL to the base engine.
- The variable valve lift modeled appears to be continuously variable valve lift (CVVL); this should be clarified by NHTSA.
- At low load (less than two bar) the CVVL benefit modeled assumes excellent combustion, and the pumping work reduction with CVVL is overstated.

Figure A-3 compares the BSFC of the NHTSA Base Engine Map to the IAV Gasoline Engine2 Map with the key findings highlighted.

[49] *Id.* at 5-506, Figure 5.201.

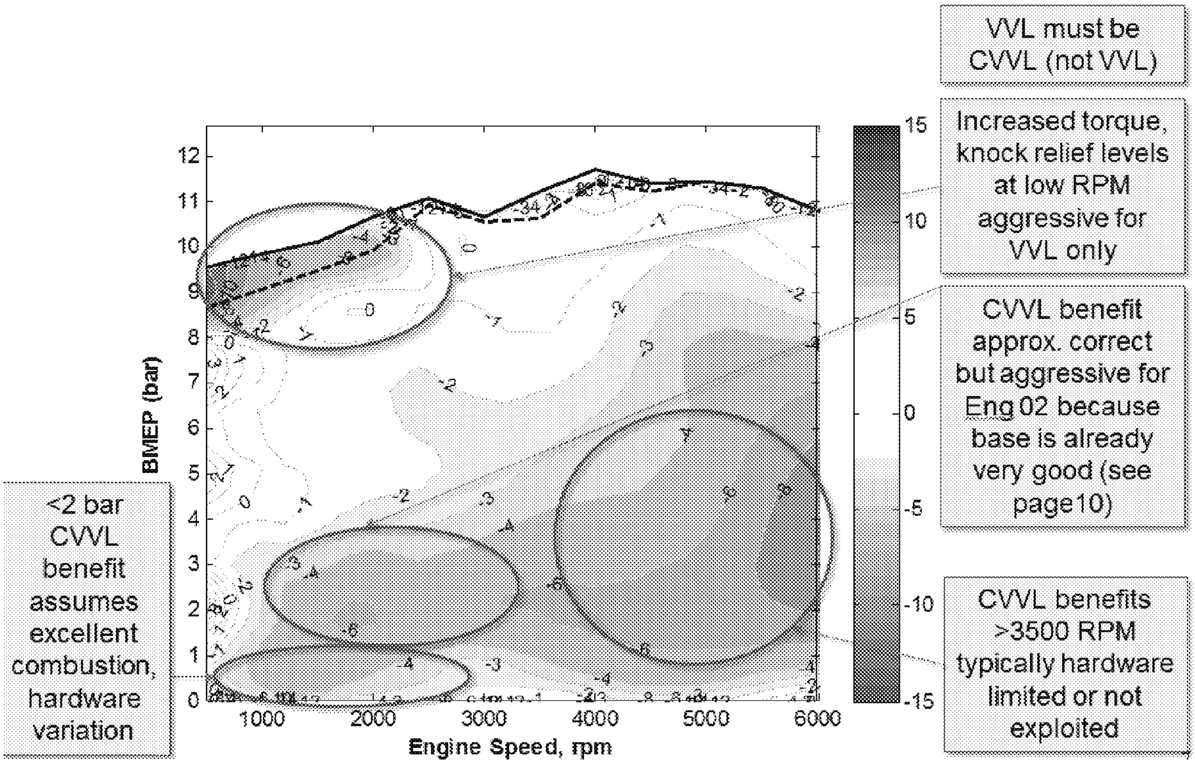

Figure A-3: Comparison of IAV Gasoline Engine2 Map to NHTSA Base Engine Map

Concerns with IAV Gasoline Engine3 Map

IAV Gasoline Engine3 Map[50] adds GDI technology and increases compression ratio by 0.8. When compared to IAV Gasoline Engine3 Map and the Honda 2.4L engine map the following observations are made:

- The GDI pump friction isn't properly taken into account (Figure 1-4).
- Optimistic knock relief assumptions are used (Figure 1-4).
- Aggressive CVVL assumptions for low load operation were made across the speed band (Figure 1-5).
- The pumping work reduction is overstated, especially considering that the benchmark Honda engine used for comparison here is already a 2-Step VVL engine (Figure 1-5).

Figures A-4 and a-5 below capture the BSFC comparison with the key findings. Figure A-4 is a comparison to IAV Engine2 Map to isolate estimated GDI benefits. Figure A-5 is a comparison to the USCAR benchmarked Honda 2.4L engine with similar technologies.

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[50] *Id.* at 5-506, Figure 5.202.

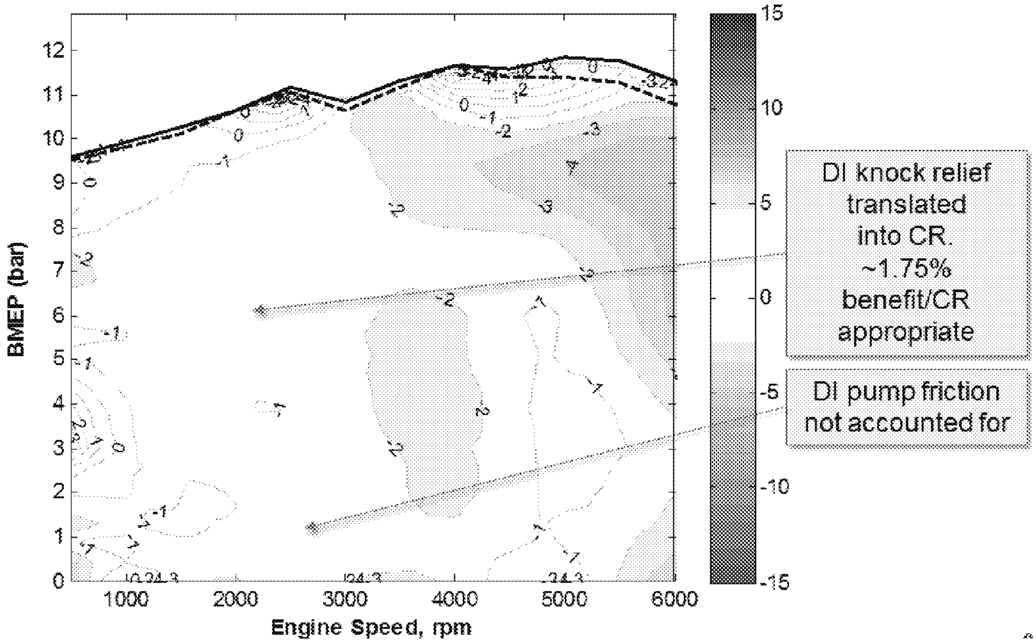

Figure A-4: Comparison of IAV Engine3 Map to IAV Engine2 Map

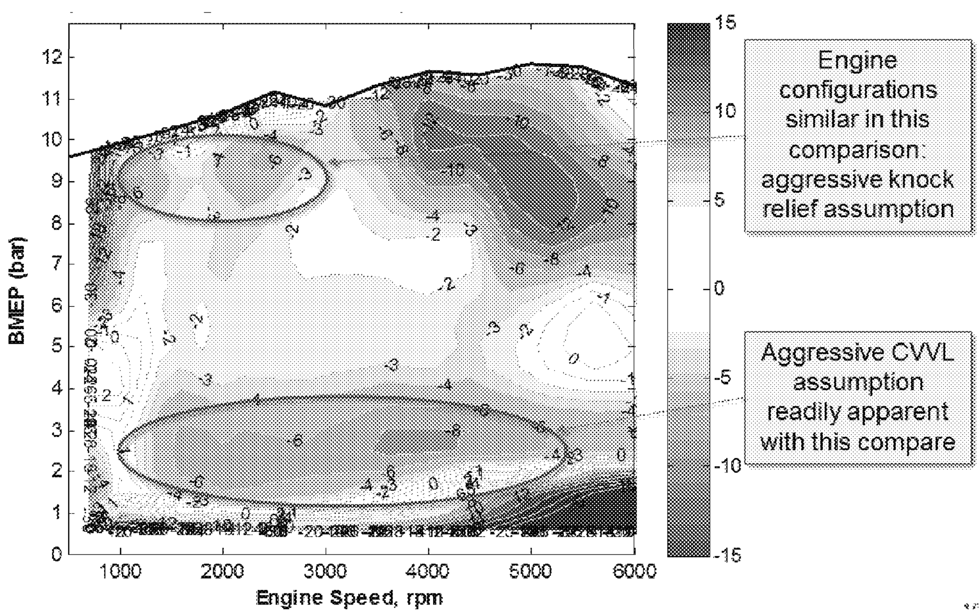

Figure A-5: Comparison of IAV Engine3 Map to Honda Accord 2.4L Engine

Concerns with IAV Engine4 Map

The following issues were identified with IAV Engine4 Map,[51] which adds cylinder deactivation technology to IAV Engine3 Map:

- The typical range of cylinder deactivation for production engines is limited to engine operation greater than 1,000 RPM to avoid idle interaction. However, IAV Engine4 Map does not display a low RPM limitation.
- Low load two-cylinder deactivation benefit is typically limited to the value seen at one bar brake mean effective pressure (BMEP). The IAV Engine4 Map suggests benefits below the one bar threshold and the map is overly optimistic in this area.
- The cylinder deactivation control system hysteresis for the transitions in and out of cylinder deactivation mode has been neglected.
- The approach of using a single map to characterize engines with cylinder deactivation technology may not take into account the transitional fuel usage during transitions in and out of cylinder deactivation mode.

Figure A-6 below captures the BSFC comparison with the key findings.

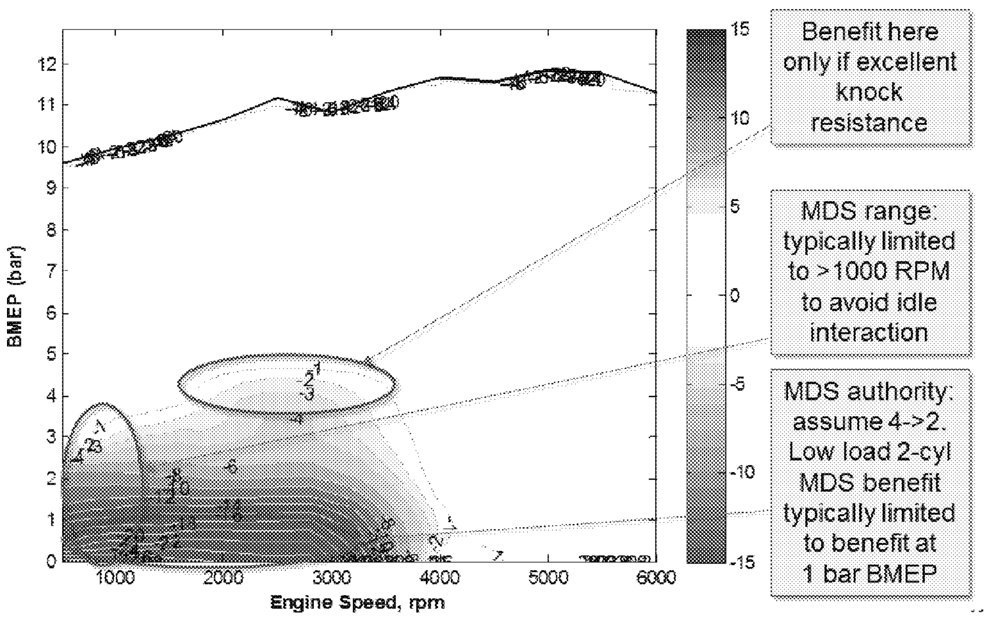

Figure A-6: Comparison of IAV Engine4 Map to IAV Engine3 Map

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[51] *Id.* at 5-507, Figure 5.203.

Concerns with IAV SOHC Engine Maps

There are broad concerns with the four engine maps with single overhead cam (SOHC) technology. These include IAV Engine Maps 5b,[52] 6a,[53] 7a,[54] and 8a.[55]

- All four engine maps assume a large friction reduction (0.1 bar) across the board.
- Additional losses, due to loss in Effective Expansion Ratio (EER) and the change to a fixed overlap volume (OLV), are not taken into account.
- Lower RPM torque reduction does not appear to be accounted for accurately.
- The benefit in the 2-4 bar region appears to be overstated given that the cams cannot move relative to each other in SOHC engines.

Figures A-7, A-8, A-9, and A-10 below capture the BSFC comparisons to with the key findings:

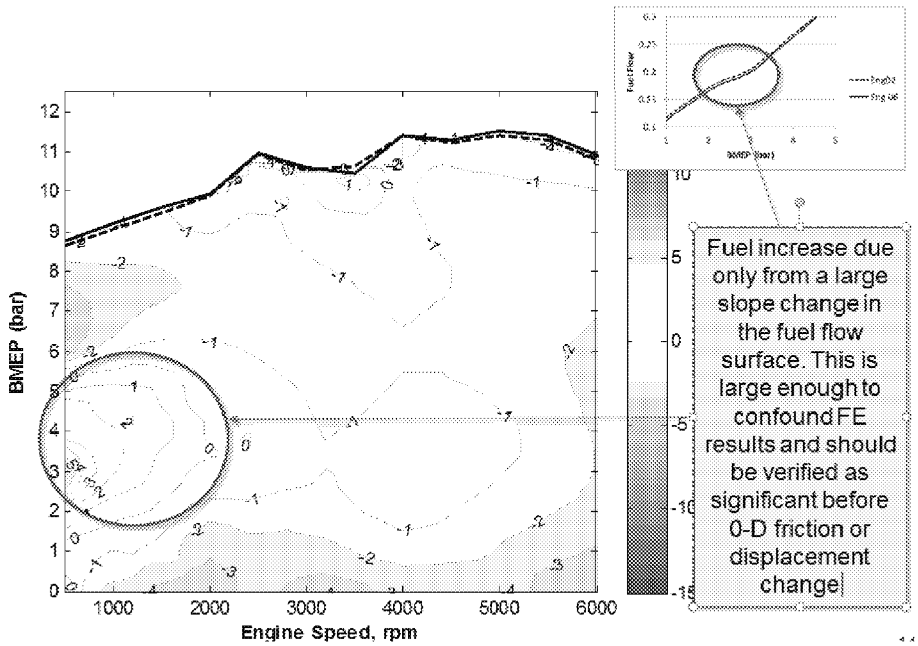

Figure A-7: Comparison of IAV Engine 5b Map to NHTSA Base Engine Map

[52] *Id.* at 5-507, Figure 5.204.
[53] *Id.* at 5-508, Figure 5.205.
[54] *Id.* at 5-508, Figure 5.206.
[55] *Id.* at 5-508, Figure 5.207.

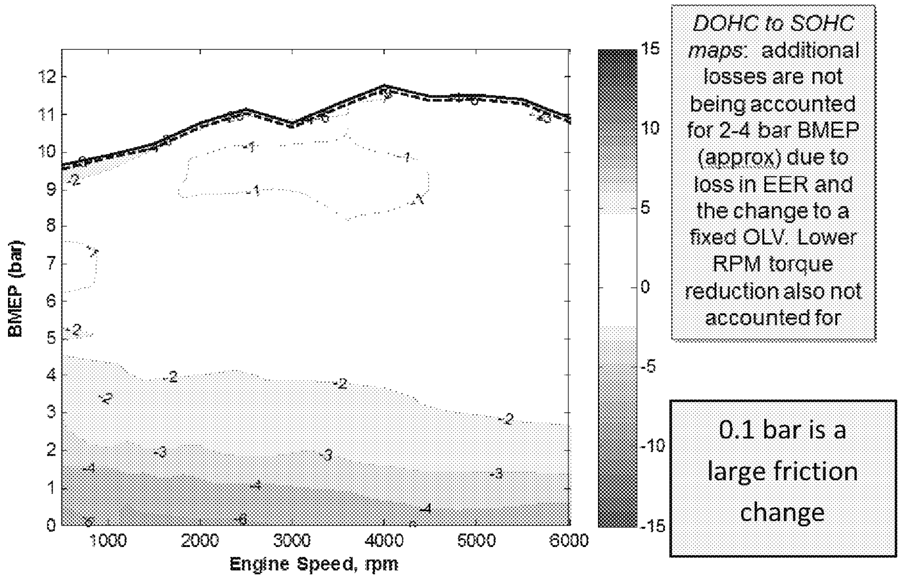

Figure A-8: Comparison of IAV Engine6a Map to IAV Engine2 Map

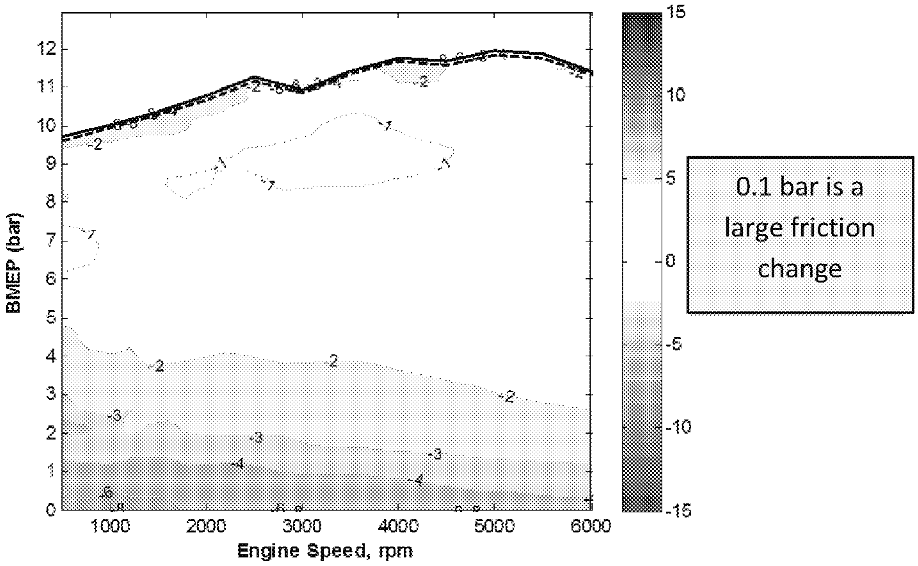

Figure A-9: Comparison of IAV Engine 7a Map to IAV Engine3 Map

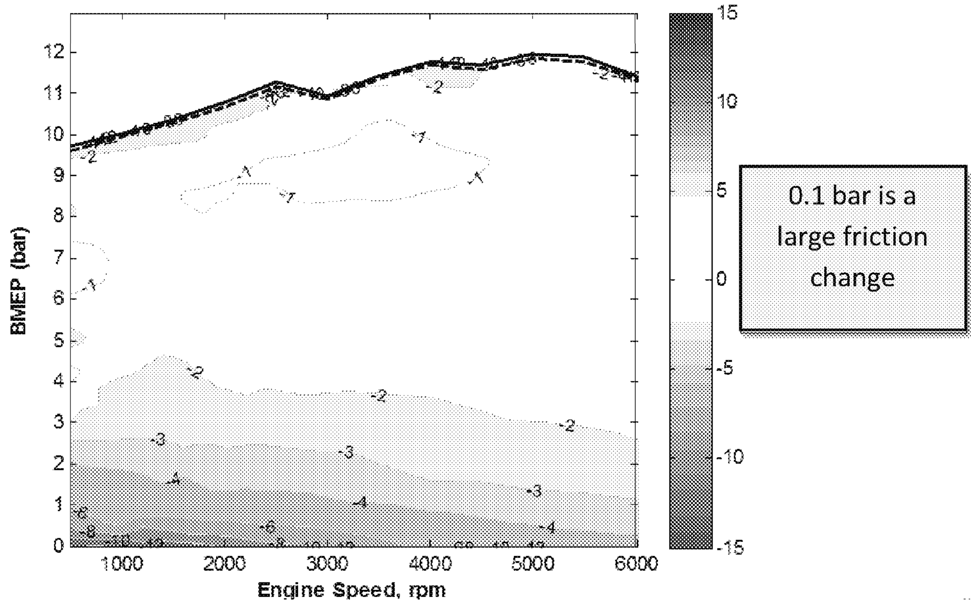

Figure A-10: Comparison of IAV Engine8a Map to IAV Engine4 Map

Concerns With IAV Boosted Engine Maps

We have concerns with IAV maps Engine12,[56] Engine13,[57] Engine14,[58] and Engine15.[59]The Draft TAR states, "IAV used gasoline with LHV = 41.3 MJ/kg for the mapping but the naturally aspirated engines were calibrated with 87 (R+M)/2 rating fuel and the turbocharged engines used 93 octane fuel."[60] The Alliance has grave concerns with NHTSA using premium fuel for turbocharged engines that do not otherwise require premium. As the Agencies are aware, automakers have to design for much lower octane commercial fuel available in the marketplace and Tier 3 91 RON certification fuel, unless the engine is one that requires premium fuel.

The broad concerns with the boosted engine maps used by NHTSA are listed below:

- The engine maps for boosted engines show best BSFC all the way to full load; this is not typical.
- For boosted engines with CEGR, the low-pressure CEGR (LPCEGR) effect appears exaggerated.

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[56] *Id.* at 5-509, Figure 5.208.
[57] *Id.* at 5-509, Figure 5.209.
[58] *Id.* at 5-510, Figure 5.210.
[59] *Id.* at 5-511, Figure 5.211.
[60] *Id.* at 5-504.

- Low load BSFC data for some boosted engine maps assumes exceptional stability or low friction.
- The optimum use of LPCEGR relative to the intake cam movement appears to result in overstated efficiency improvements.

Figures A-11 and A-12 illustrate the above issues with the key findings with the IAV Gasoline Engine12 Gasoline Engine13 maps.

Figure A-13 captures the effect of a 0-D displacement change from 1.6L to 1.2L (downsizing effect).

Figure A-14 below illustrates the effect of aggressive LPCEGR on the 1.0L 3-cylinder engine.

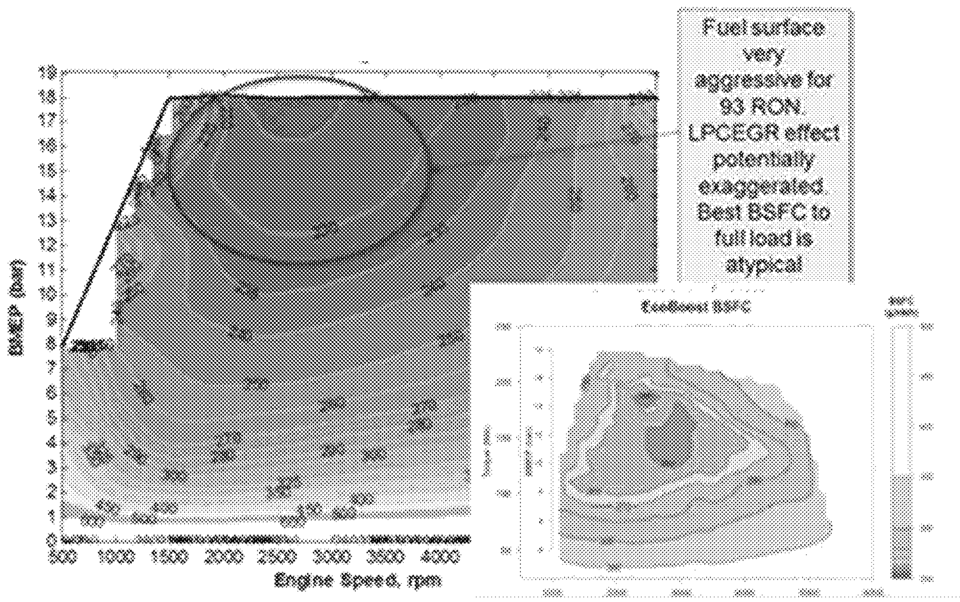

Figure A-11: IAV Gasoline Engine12 Map - Atypical Fuel Surface for Downsized Turbocharged Engines Running on 93 RON Fuel

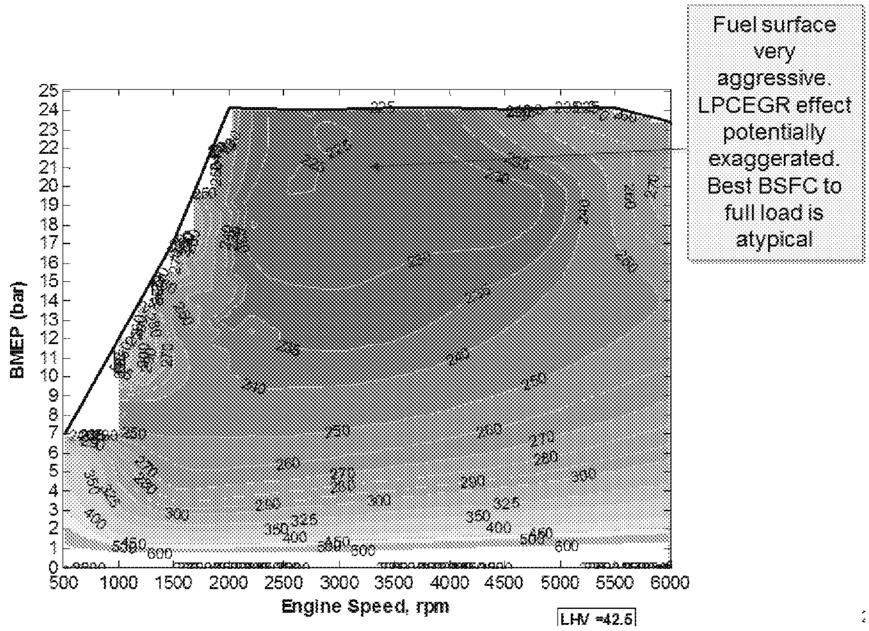

Figure A-12: IAV Gasoline Engine13 Map - Aggressive Fuel Surface With Atypical Results

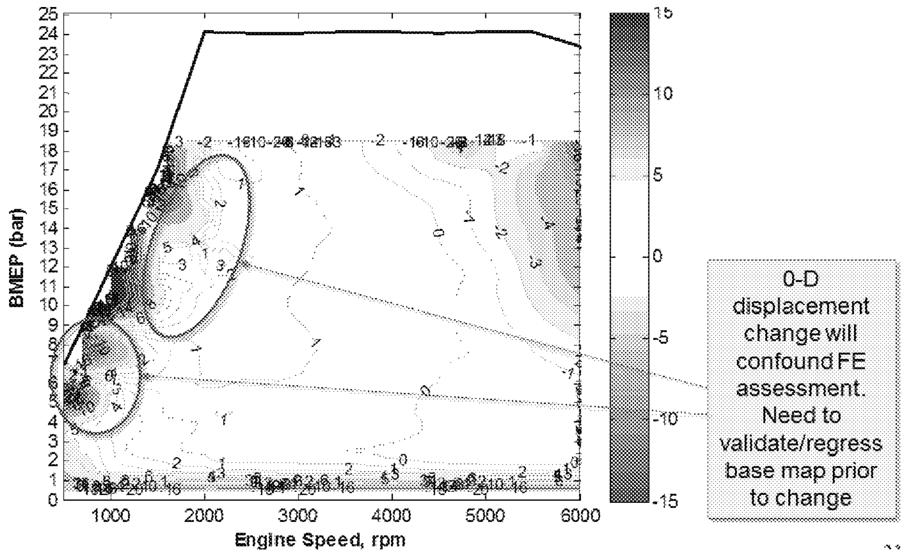

Figure A-13: Comparison between IAV Gasoline Engine12 Map and IAV Gasoline Engine13 Map; Displacement Change without Full Modeling Questionable

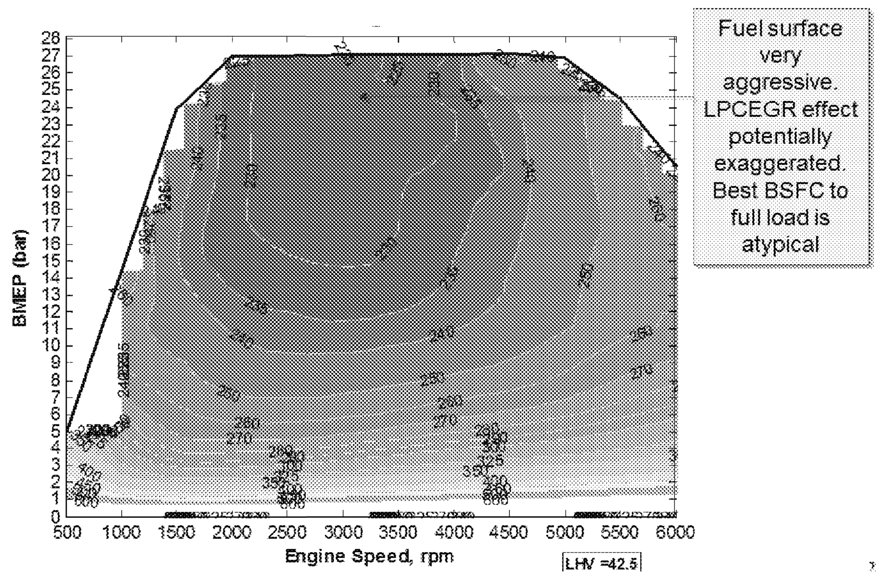

Figure A-14: IAV Gasoline Engine14 Map - Aggressive Fuel Surface With Atypical Results

Summary of NHTSA Fuel Map Findings

The primary focus on the use of the IAV engine maps appears to be the operating regions during the city and highway test cycles and thus there may have been more emphasis to precision given to the speed load points that favor the certification cycles. However, for a commercial engine package, the compromises needed to deliver acceptable engine performance at all speed load points will negatively impact the regions of the maps that are prevalent during the certification cycles.

The Alliance appreciates NHTSA accepting the feedback of automakers during the Modeling Workshop and supports its efforts to ensure that all future engine model development is performed with regular grade octane gasoline. The Alliance assumes that this work will be completed before the NPRM is published. The Alliance also supports NHTSA's commitment to develop new high-fidelity models to represent potential future technologies. However, the Agencies should also recognize that given the timeframe and all the constraints involved in bringing new engine architectures to the market, the introduction of any new technologies not already captured by the Agencies during the Draft TAR process may be beyond the broad-scale implementation framework for MY2022-2025.

Issues Applicable to Both the ALPHA and Autonomie Models

There are a number of technical flaws that are common to both the ALPHA and Autonomie models which bias the full vehicle simulations to more optimistic benefits than those anticipated by automakers.

Tier 3 Emissions

The Alliance recommends that both Agencies account for the CO_2 and FE degradation associated with Tier 3 emissions control systems and the impact of more stringent evaporative emissions regulations in their MTE analysis. The effect of the evaporative emissions regulations is further magnified for engine stop-start and HEV applications where the engine off option is constrained by the need to purge the canister for evaporative emissions requirements. The Tier 3 final rule and associated regulatory impact analysis (RIA), plus various Tier 3 docket comments, discuss this matter in detail. The Alliance will gladly work with the Agencies' technical staff to inform the appropriate models of the impact of Tier 3 emissions compliance.

CARB PM (1 mg/mi)

The Alliance recommends that both Agencies account for and include the detrimental impact of CARB particulate matter (PM) (1 mg/mi) particulate matter regulations on CO_2 and FE performance in the MY2022–2025 timeframe. The 1 mg/mi PM (1) requirement could impact approximately 40% of the fleet. The Alliance will gladly work with the Agencies' technical staff and provide guidance on how to model the impact of CARB PM (1) on future compliance.

Baseline Vehicle Electrical Loads

The Alliance suggests that the Agencies harmonize around the NHTSA base electrical accessory loads of 240 W. The base electrical loads used by the Agencies differ by a factor of two. The EPA fleet average base load of 490W is too high to accurately represent a fleet average. Table A-1 below shows what the Agencies are using for baseline electrical loads while Table A-2 demonstrates the two-cycle average base load in watts for a sampling of North American products across several vehicle segments. While there are some vehicles that do reach 490W and greater, the average two-cycle base load of the sample vehicles is 387W. By inflating the base electric load, EPA has effectively overestimated the effectiveness of load reduction technologies.

Table A-1: Agencies Baseline Electrical Loads

Assumption	Base Load	Reference	TAR Document
EPA	490 W	Chevrolet Malibu and some others	Page 5-266
NHTSA	240 W	ANL Autonomie Software	Pages 5-503 and 5-526

To assist the Agencies in developing an accurate and harmonized start point, the Alliance is providing the following benchmarking data from a collection of late model vehicles.

Table A-2: Electrical Base Load Benchmarking Data[61]

Vehicle	2-Cycle Average (W)
2013 Lincoln Navigator L	430
2015 Cadillac Escalade ESV	360
2016 Cadillac ATS	293
2014 Chevy Cruze LTZ	306
2014 Chevy Sonic LTZ	228
2015 Chevy Tahoe LTZ	368
2013 Audi A8 L 4.0T	578
2013 Mercedes GL450	581
2014 BMW X5 xDrive35i	491
2016 BMW X5 xDrive35i (Start/Stop ON)	519
2015 Lexus NX200t	315
2015 Volvo XC60 T6 DRIVE-E	420
2015 Kia Soul !	298
2015 Hyundai Elantra Limited	244
2016 Honda Pilot Elite (Start/Stop OFF/ON)	516
	517
2016 Ford Fusion	275
2016 Ford F-150	318
2015 GMC Sierra	291
Vehicle Average	**387**

To further assist the Agencies in accurate electric load modeling, the Alliance is providing Table A-3 from the American Automotive Policy Council (AAPC) Heavy Duty Greenhouse Gas Phase 2 public comments.[62] This table demonstrates a typical breakdown of electrical load.

[61] Courtesy of Ford Motor Company and General Motors.
[62] Docket ID EPA-HQ-OAR-2014-0827-1238.

Table A-3: 2015 GMC Sierra Light-Duty Pickup 6.2L V8 Power Consumption Test Data (Watts)[63]

	FTP City	FTP	US06
Electrical Power			
Total Load Power	319.9	254.8	286.5
MGU Power	410.5	248.5	274.5
12V Batt Power	-	6.34	12.00
12V Batt Voltage	14.43	12.76	12.70
BCM 6 Power	31.71	10.97	21.28
BCM 7 Power	23.12	4.06	14.71
Powertrain Power			
Engine Management System			
ECM Batt Power	3.69	3.74	3.67
ECM IGN Power	0.37	0.29	0.29
ECM Power	26.38	31.68	37.96
Fuel Pump MOD Power	29.79	28.41	31.20
Ignition Coil Even Power	6.22	7.49	9.50
Ignition Coil Odd Power	6.24	7.53	9.46
MAF Power	1.57	1.46	1.53
O2 HTR Post Power	13.52	6.89	3.57
O2 HTR Pre Power	40.76	34.49	22.18
Propulsion Control Power			
TCM Batt Power	40.61	23.17	27.77
Thermal			
Propulsion Thermal Power			
Cooling Fan 1 Power	4.45	13.16	15.94
Cooling Fan 2 Power	3.99	10.81	12.39
HVAC Thermal Power			
AC Clutch Power	0.00	0.01	0.01
Front Blower Power	0.05	0.07	0.13
Chassis			
Chassis Power			
ABS Pump Power	0.03	0.09	0.03
ABS Valve Power	3.93	3.66	3.67
EPS	3.56	3.06	3.24
Body/VASS Power			
CHMSL Power	8.25	1.75	5.40
Infotainment/Telematics Power			
Audio AMP Power	7.90	7.07	6.99
OnStar Power	3.18	3.16	3.18
Radio NAV Power	12.37	12.09	12.05
Saftey Active/Passive Power			
Airbag Power	3.88	3.86	3.86

[63] *Id.* at 43.

Gasoline Fuel Properties

The Alliance recommends that NHSTA and EPA harmonize and use regular grade Tier 3 test fuel for all future analysis, unless testing "premium required" engines. We note that the mixed use of fuel by both Agencies made detailed comparisons between some technologies impossible to complete during the 60-day comment period.

In addition, Tier 3 test fuel also contains 10% ethanol, lowering the energy content of the fuel. The Alliance supports EPA's ongoing efforts to develop appropriate adjustments to account for the resulting lower fuel economy.

Engine Downsizing

Engine downsizing is inherent to the Agencies' estimates of benefits. For example, if a technology adds performance to a vehicle, the Agencies readjust the vehicle design, usually with engine downsizing, to maintain performance neutrality, and the subsequent benefits of the downsized engines are added to benefits of the technology.

The Agencies fail to consider the availability of downsized engines

When adjusting engine size to maintain performance, EPA assumes that any resulting engine displacement will be available, maximizing the modeled benefits of various technologies. In practice, manufacturers have a limited number of engine displacements to choose from and will likely select the size of engine that maintains or improves performance.[64] EPA's assumption of infinite engine displacement availability yields unreasonably optimistic results. Flexible manufacturing techniques, already widely in-use, do not allow for infinite displacement variation.

It is our understanding that NHTSA has provided some constraints when assuming the availability of downsized engines. We support this direction and urge NHTSA to verify that its methodology is consistent with normal business practices of sharing engines across multiple platforms and minimizing the total number of displacements built given engine plant capacity and capital constraints.

The Agencies fail to consider displacement to mass ratio constraints

As is discussed further in the Alliance's specific comments on downsized and turbocharged engines, displacement to vehicle mass ratio (D/M) provides a simple means to assess whether the degree of downsizing will find market acceptance. By failing to consider this parameter, the Agencies could model engines which will not gain customer acceptance. We recommend that

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[64] *See* further discussion in Appendix E regarding customer expectations for continuous improvement, as opposed to maintaining a previous generation's features.

both Agencies review the comments on downsized turbocharged engines and add a constraint which considers the displacement to mass ratio.

The Agencies do not account for top gear grade-ability

A key metric needed to maintain performance neutrality is top gear grade-ability. In contrast, the main metric by which performance neutrality is measured by the Agencies is 0-60 acceleration time. As discussed in the Draft TAR Section 5.3.1.2, EPA considered several other metrics including 0-30 time, ¼ mile time, 30-50 passing time, 50-70 passing time, and trailer towing (for trucks only). However, EPA noted that "[w]ithin the [2012] FRM analysis, the 0-30 mph and 0-60 mph performance window criteria were found to be sufficient to maintain equivalence with other indicators of vehicle performance and utility, including trailer grade-ability."[65] The common element of most of the Agencies' performance tests is that they occur in the lower gears of transmission operation. But none of the metrics evaluated is a substitute for top gear grade-ability.

Top gear grade-ability is the ability of a vehicle to negotiate a grade in top gear without downshifting. If the top gear ratio is too low, every time a driver encounters a small hill or wants to accelerate from a steady speed on a level road, the transmission would have to downshift. Unnecessary downshifting leads to customer acceptance issues. To avoid this problem, manufacturers check for top gear grade-ability. EPA and NHSTA should perform a similar check, by vehicle (since engine displacement, transmission, and final drive ratios are critical to this metric), to verify that grade-ability is not degraded by downsizing.

It should be noted that grade-ability is one of the metrics a 2011 report by the National Research Council identified,[66] and EPA quoted on page 5-225 of the Draft TAR, as being required for "truly equal performance." Top gear grade-ability should also be relatively easy to calculate and compare.

Lumped Parameter Model

The Alliance and its member companies support full vehicle simulation over the LPM. We recognize and support NHTSA's intent to utilize full vehicle simulations for all modeling to inform its *de novo* rulemaking for MY2022-2025.[67] Manufacturers generally rely on full vehicle simulations to estimate the benefits of technology packages applied to future vehicles when

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[65] 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, (EPA-420-D-16-900, July 2016) at 5-226.
[66] "Assesssment of Fuel Economy Technologies for Light-Duty Vehicles." National Academy of Sciences, National Research Council to the National Academies. 2011. 62.
[67] 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, (EPA-420-D-16-900, July 2016) at 5-458, Figure 5.148.

developing their compliance plans due to their greater accuracy, ability to model specific vehicles, and capability in modeling the full range of customer operating conditions. Both EPA and NHTSA agree that full vehicle simulation models provide superior results when estimating the benefits of combinations of technologies.[68]

Novation Analytics identifies the Lumped Parameter Model as a Key Source of Technology Package Benefit Assessment Errors

In its Fleet Level Tech Effect Study[69], Novation Analytics identified that projections of technology penetration from the 2012 FRM at a fleet level were insufficient to meet the MY2021 and MY2025 standards. The Alliance requested that Novation Analytics explore this issue in more detail.[70] In so doing, Novation Analytics found that the LPM yields implausible results, particularly for vehicles with higher baseline efficiency.

Novation Analytics identified the following issues with the LPM:[71]

- The vehicle's baseline (i.e. starting point) efficiency is critically important for projected benefits of additional technology, but this is not accounted for in the LPM.
- The linear regression models within the LPM are not based on the first order determinants of powertrain efficiency and, therefore, do not properly capture the fundamental trends. This leads to a consistent over-projection [of technology benefit] when applied to efficiency-oriented vehicles (which are often the high volume vehicles).
- The [A]gencies' modeling processes do not recognize the inherent variability of efficiency within the light-duty fleet, treating all products within a category as equal. Without limits in the process, this approach results in overprojection of the most efficient vehicles.
- No procedure or methodology is currently in place to check the outcomes of the [LPM's] technology effectiveness projection process against logical efficiency metrics and limits. Without such checks, the outcomes can exceed plausible limits. (The Alliance further notes, to our knowledge, EPA has not checked the results obtained from the LPM against the ALPHA model or actual vehicles, except in the limited cases where the LPM is specifically calibrated to the ALPHA model results.)

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[68] *Id.* at 5-271 and 5-458.
[69] "Technology Effectiveness – Phase 1: Fleet-Level Assessment." Novation Analytics. 2015.
[70] "Technology Effectiveness – Phase II: Vehicle-Level Assessment." Novation Analytics. 2016. 12.
[71] *Id.* at 8.

We refer EPA to the Novation Vehicle Level Tech Effect Study,[72] particularly the section entitled "Identification of Agency Modeling Process Issue(s)" for further discussion on why the LPM is likely to overestimate the benefits of technology for some vehicles.

Further analysis of the Lumped Parameter Model by the Alliance also indicates potential problems

The Alliance performed the following analysis in an effort to better understand LPM and to identify specific areas of concern. The Alliance recognizes that in doing so, we exercised the LPM in a different manner, but we are confident that the method was sound and the results worthy of comment and further discussion with the Agencies.

The reason we had to approach the analysis this way is because the LPM shows fuel consumption improvements relative to a "null" vehicle. Manufacturers can model new technology packages, but lacking the counterpart null vehicle data, we cannot make direct comparisons.

To circumvent this lack of data and still provide timely insight on model accuracy, the Alliance analyzed the absolute CO_2 predictions from the LPM. We acknowledge this differs from the LPM's intended function which is to calculate the percent improvement from null.

For comparison, the actual CO_2 data from the MY2014 fleet was used. All of the data used to perform this analysis was contained in files supplied by EPA in support of the Draft TAR.

The following describes the specific process followed in the analysis and the results obtained.

Although the EPA provides an executable graphical user interface (GUI) of its LPM for general public review,[73] the actual tool used to inform EPA's OMEGA model is the "Vehicle Energy Effects Estimator" located within the OMEGA "Machine" preprocessor spreadsheets.[74]

To generate the CO_2 estimates from the LPM, the MY2014 data compiled by EPA for the Draft TAR was used:

- Column V of the "Vehicle" sheet of "Market_Ref_in2025B_central.xlsm" shows the baseline CO_2 values for the individual MY2014 vehicles.
- Column GE of the same sheet and file shows the baseline (Tech Package 0) technologies.

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[72] *Id.* at 38.
[73] Lumped Parameter Model (LPM) for Light-Duty Vehicles. Environmental Protection Agency. Accessed September 19, 2016. https://www3.epa.gov/otaq/climate/lpm.htm.
[74] Electronic mail from Michael Olechiw, EPA to Michael Hartrick, Alliance. August 19, 2016.

- Columns AO through AR of the "Baseline" sheet of "Machine_2014B_rpe.xlsb" show road load at 50 MPH, equivalent test weight (ETW), rated torque, and rated power, respectively.

To perform the analysis, the technology information was extracted from Tech Package 0 for each vehicle and then applied to the "Vehicle Energy Effects Estimator tool" (Estimator) using the "Custom" vehicle type. The Estimator then provided a CO_2 estimate from cell M29, the result of which can be compared to the actual CO_2 from the MY2014 baseline vehicle.

An Excel macro was developed to automate this routine so that every vehicle could be analyzed. The limited number of EVs, range-extended electric vehicles (REEVs), compressed natural gas (CNG), and propane-fueled vehicles in the dataset were excluded from the analysis to minimize noise.

The results of this process, after sorting for conventional technologies (no hybrids, turbocharged engines, or eight-speed transmissions), are plotted below in Figure A-15. In this and the following figures, results below the line show data where the LPM predicted lower CO_2 than the vehicle actually emitted. Conversely, points above the line show when the vehicle was better than the LPM estimate. The standard error for this data is 31 g/mi, but the overall slope calculated as a best-fit line is about 2% from actual.

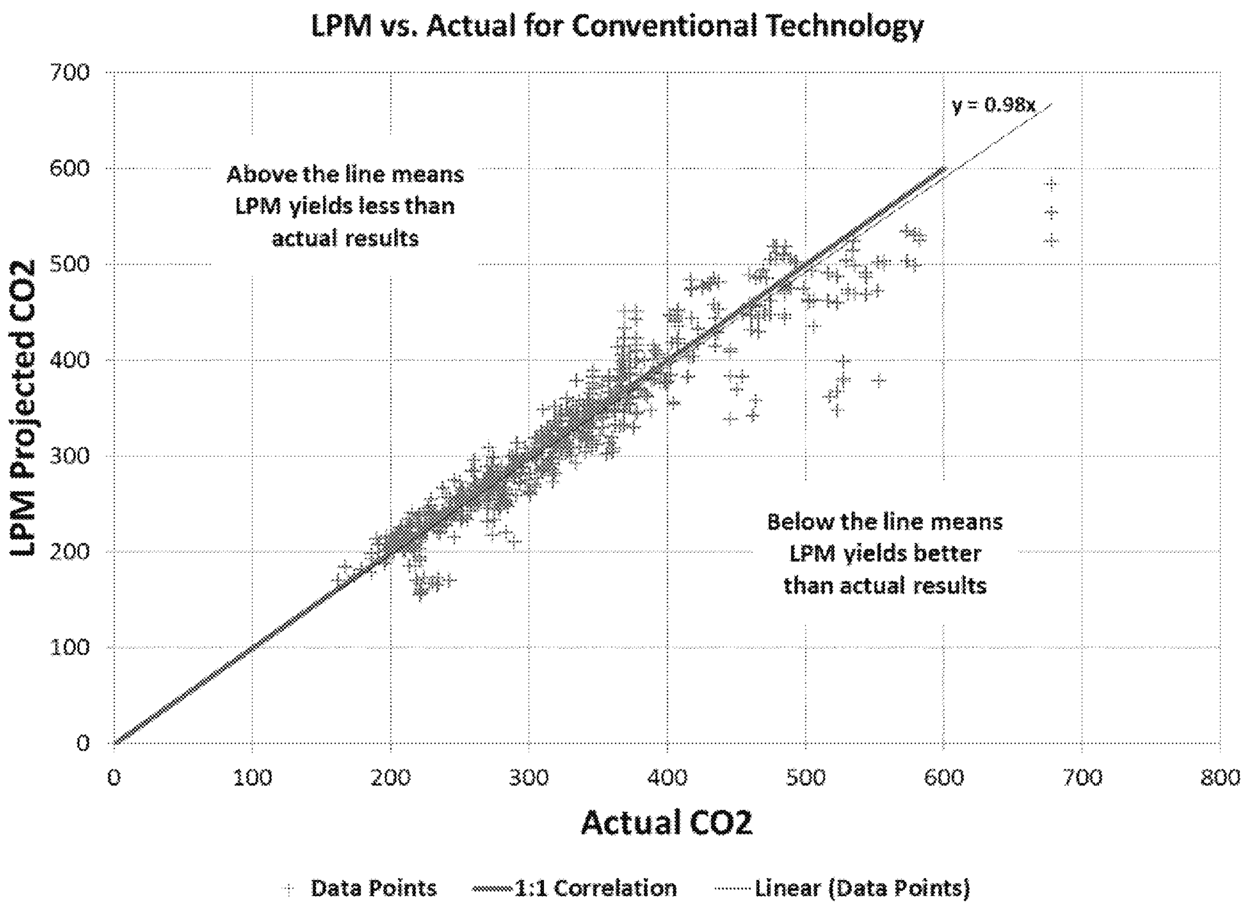

Figure A-15: Lumped Parameter Model compared to Test Data

Figure A-16 shows the data after filtering for only eight-speed transmissions. Here the standard error has increased to 49 g/mi, but of greater concern is the change in slope of the best-fit line. The overall trend shows that the LPM is more optimistic by 12% than what manufacturers have, on average, been able to deliver. This is the powertrain technology, aside from variable valve timing, with the highest projected penetration (~90%) from the OMEGA model.[75]

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[75] 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, (EPA-420-D-16-900, July 2016) at 12-29, Table 12.33.

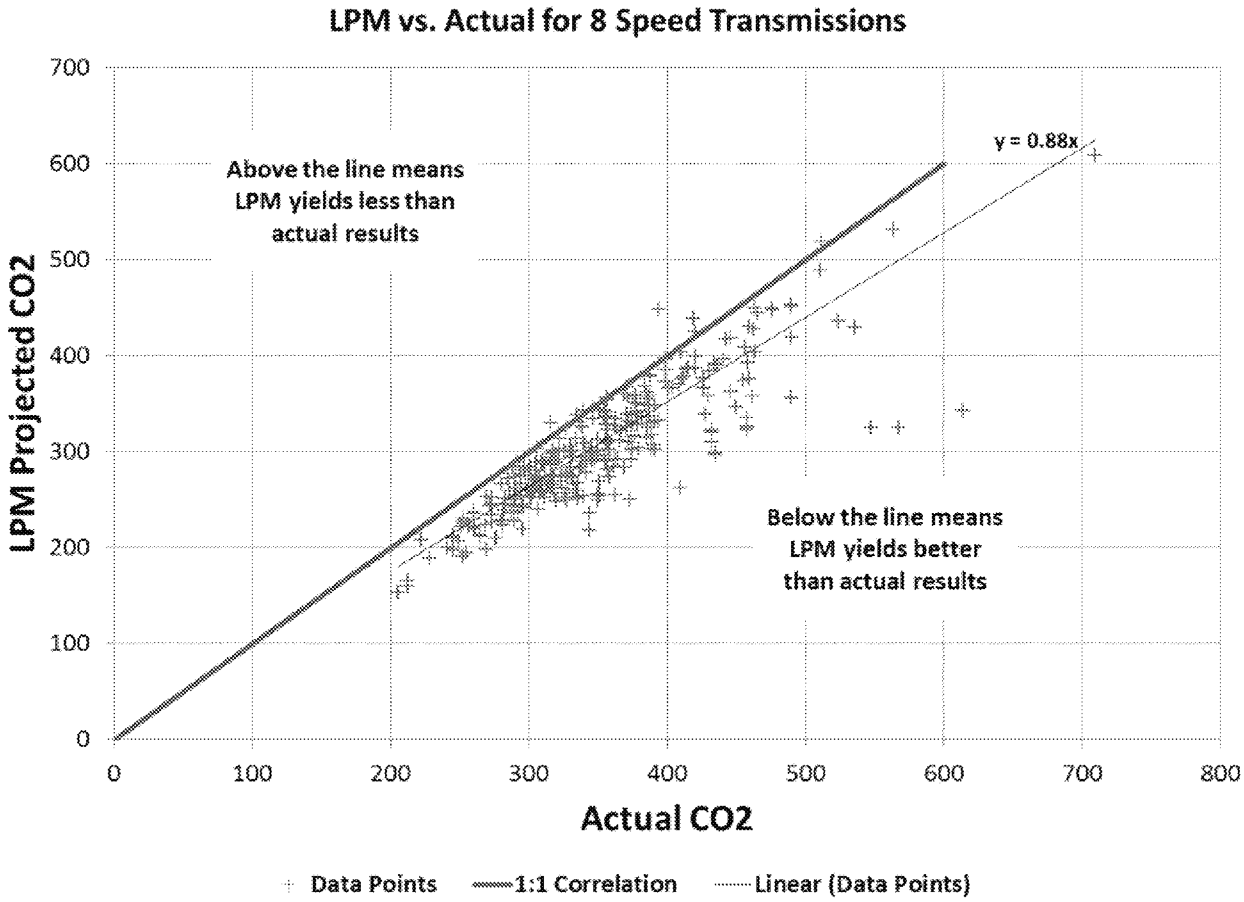

Figure A-16: Lumped Parameter Model compared to Test Data of Vehicles with 8-Speed Transmissions

Two major concerns from this study are the accuracy of the LPM and an optimistic bias for some technologies like the eight-speed transmission (shown above).

The Alliance recognizes that no model is ever perfect, but given the impact of these regulations on manufacturers, we ask that EPA use every available method to improve its tools. Analyses such as this should be used to identify the greatest errors and then develop strategies to resolve them, if that is even possible. That is, at some point the broader question would be whether EPA should just use full vehicle simulations as NHTSA has done.

The Alliance looks forward to sharing and discussing this study with EPA to advance the MTE process.

Full vehicle simulation is practical to implement to inform the OMEGA and Volpe models.

The EPA contends that "developing and executing every possible combinations [sic] of technology directly in a fleet compliance model using full vehicle simulation would not be practical to implement."[76]

Setting aside whether there is a need to execute such a model "directly in a fleet compliance model," the Alliance disagrees with EPA's assessment that "full vehicle simulation would not be practical to implement" to inform the OMEGA model. NHTSA has already indicated that it intends to use full vehicle simulation modeling to inform the Volpe model and visually described a "large scale simulation process" using multiple networked processors as an enabler in Figure 5.148 of the Draft TAR.[77] Similarly, Novation Analytics has proposed to the Alliance that it replicate every simulation used to inform OMEGA with its full vehicle simulation software *Energy* for comparison.

Furthermore, manufacturers must evaluate various product plans for compliance, in an exercise similar to those efforts undertaken by the Agencies in their use of the OMEGA and Volpe Models. Manufacturers face the same challenges in evaluating a broad range of technology packages for individual vehicles and are able to adequately inform their own efforts using full vehicle simulations as opposed to models like the LPM.

Alliance Recommendations Regarding the Lumped Parameter Model

The Alliance recommends the following:

1. Cease use of the LPM as a tool to inform the OMEGA and Volpe models in favor of full vehicle simulation modeling such as that provided by ALPHA and Autonomie.

2. If EPA cannot identify the means to implement the Alliance's recommendation to cease use of the LPM,[78] the "LPM should be enhanced and upgraded to incorporate the key vehicle and powertrain parameters which determine powertrain efficiency."[79]

3. If the EPA continues use of the LPM, it should, at minimum, perform a quality check of the LPM results against a variety of actual vehicles (in particular, relatively higher efficiency vehicles to which the LPM was not specifically calibrated). The results of these quality checks should be provided with the LPM documentation for public review.

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[76] *Id.* at 5-271.
[77] *Id.* at 5-459.
[78] As previously discussed, the Alliance does not see a valid reason why EPA cannot use full vehicle simulation modeling in place of the LPM given that manufacturers, consultants, and NHTSA have all found a means to do so.
[79] "Technology Effectiveness – Phase II: Vehicle-Level Assessment." Novation Analytics. 2016. 44.

Plausibility Checks

Model inputs, design, and underlying assumptions play a key role in determining the accuracy of the final output of any vehicle-level technology package simulation. In the Novation Analytics Vehicle Level Tech Study,[80] a series of three plausibility checks designed for use as high-level[81] liberal checks of modeled powertrain effectiveness were designed. The Alliance recommends these plausibility checks to EPA and NHTSA as a filter for their modeling outputs. Outputs which fail these simple plausibility checks should be re-examined for potential errors in the modeling inputs or in the model design itself. Further information describing these plausibility checks, the limits chosen (and justification thereof), and applicability to various types of modeling can be found in the "Plausibility Assessment Methodology" section of the Novation Vehicle Level Tech Study.[82] The plausibility checks are:

1. Conversion Efficiency Proxies: This plausibility check is based on the assumption that future technology will not exceed the level of other more efficient technologies already demonstrated in the fleet (e.g. diesel engine efficiency as a proxy for future advanced gasoline engine efficiency). The Novation Analytics analysis of the 2012 FRM indicated that 40% of the samples exceed this plausibility check.[83]

2. On-Cycle-to-Peak Engine Efficiency Ratios: This plausibility check is based on differences between the operating conditions on the city and highway cycles and the peak efficiency operating point. In the 2012 FRM, some of the Agency modeled on-cycle efficiency results actually exceeded the peak engine efficiency (an impossible condition to achieve).

3. City-to-Highway Cycle Efficiency Ratios: This plausibility check uses historical ratios of highway and city cycle efficiency[84], adjusted for future improvements. This check can only be applied to full vehicle simulation results (the LPM does not provide separate city and highway cycle results). Novation Analytics checked the Ricardo simulation results (used, in part, to calibrate the LPM) and determined that in *all* cases, the results failed this plausibility check.

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[80] *Id.*

[81] The limits chosen are designed to allow as many passing results as possible and to only flag issues when there is a near or absolute certainty that the tested outputs are implausible.

[82] *Id.* at 20.

[83] *Id.* at 32.

[84] Highway cycle operation is typically more efficient than city cycle operation for conventional internal combustion engine-powered vehicles.

Full Vehicle Simulation Modeling Quality Control Checks

The Alliance recommends that the Agencies incorporate and make readily available quality control parameters that can be used to verify the validity of model results in all output files. At a recent workshop on their modeling efforts to inform the MTE,[85] the Agencies and automakers freely and openly discussed the beneficial merits of including quality control checks in the modeling data. The Alliance recommends that the Agencies harmonize the entire quality control check list and incorporate it into the next phase of the MTE. The Alliance also suggests adding these additional parameters:

- Top gear N/V ratio at 50 mph
- Tire Size (rev/mile)
- UDDS Phase 1 Fuel Consumption (gallons/mile)
- UDDS Phase 1 Cycle Energy (joules) CE per SAE J2951
- UDDS Phase 1 CO_2
- UDDS Phase 2 Fuel Consumption (gallons/mile)
- UDDS Phase 2 Cycle Energy CE per SAE J2951
- UDDS Phase 2 CO_2
- UDDS Phase 3 Fuel Consumption (gallons/mile)
- UDDS Phase 3 Cycle Energy CE per SAE J2951
- UDDS Phase 3 CO_2
- UDDS Phase 4 Fuel Consumption (gallons/mile)
- UDDS Phase 4 Cycle Energy CE per SAE J2951
- UDDS Phase 4 CO_2
- Highway Fuel Consumption (gallons/mile)
- Highway Cycle Energy CE per SAE J2951
- Highway Phase 4 CO_2
- US06 City Fuel Consumption (gallons/mile)
- US06 City Cycle Energy (joules) CE per SAE J2951
- US06 City CO_2 (gallons/mile)
- US06 Highway Fuel Consumption (gallons/mile)
- US06 Highway Cycle Energy (joules)
- US06 Highway CO_2 (gallons/mile)
- Fuel Type (gasoline 87 AKI, gasoline 91 AKI or premium, diesel, etc.)

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[85] NHTSA, EPA and CARB workshop on technology effectiveness modeling methodologies for the midterm evaluation draft technical assessment report (TAR) analysis for CAFE standards and GHG standards. National Highway Traffic Safety Administration. Accessed September 25, 2016. http://www.nhtsa.gov/Laws+&+Regulations/CAFE+-+Fuel+Economy/nhtsa-epa-carb-workshop-03012016.

- Fuel Net Heating Value (MJ/kg)
- Fuel Carbon Weight Fraction
- Fuel Specific Gravity
- 2025MY Footprint (ft^2)
- Supplemental Tier 3 Catalyst Heating Penalty (joules)
- Supplemental Tier 3 Intake Restriction Loss (joules per phase)
- Supplement Tier 3 Exhaust Backpressure Loss (joules per phase)
- Cycle Electrical Power for Powertrain (joules)
- Incremental Cycle Mechanical and Electrical work for CEGR (joules)

Vehicle Performance Metrics

The Alliance recommends that the Agencies agree on a common set of vehicle performance metrics that include on-road driving. While EPA uses simple 0-30 mph and 0-60 mph metrics, NHTSA utilizes a more comprehensive set that takes into account actual customer use and acceptance and reflects reasonable trends in the fleet. The Alliance recommends that EPA adopt and utilize the NHSTA set of vehicle performance metrics to avoid inadvertently developing analytic solutions that work for laboratory testing, but do not meet customer requirements. However, the Agencies must both use a more realistic set of performance standards, especially acceleration as NHTSA uses a target of nine seconds. This is not representative of today's fleet and is even inconsistent with the findings in EPA's Fuel Economy Trends Report[86] which states that "since the early 1980's there has been a clear downward trend in 0-60 time."[87] Looking at the acceleration of the top 120 vehicle models sold in 2015 shows the average sales-weighted 0-60 time to be just over seven seconds.[88] Furthermore, we recommend that both Agencies utilize current fleet performance statics, and account for differences between vehicle segments.

Common performance metrics that should be considered are listed here:

- 5% grade at 65 mph top gear
- 3% grade at 75 mph in penultimate gear
- 0 - 60 mph at curb weight
- 0 - 30 mph at GVW acceleration time (turbo lag metric)
- 30 - 50 mph passing
- 60 - 80 mph passing time
- 0 - 60 mph at GVWR
- 60 - 0 mph stopping distance dry pavement

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[86] Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 Through 2015, (EPA-420-R-15-016, 2015).
[87] *Id.* at 33.
[88] *Id.* at 33.

- 60 - 0 mph stopping time
- SAE J2807 Trailer Tow Rating for Full Size Trucks and SUV's
- 0 - 60 mph 5500 ft above sea level
- 50 - 70 mph passing at GVW 5500 ft above sea level
- Top gear grade-ability

These metrics must be considered by manufacturers to ensure customer satisfaction and therefore should be considered by the Agencies when modeling future technology packages.

Appendix B: Comments on Technology Specific Effectiveness and Cost

The Alliance provides the following comments on specific technologies described in the Draft TAR. Supplemental comments may be submitted at a later date.

Advanced Atkinson Cycle Engines with CEGR and Cylinder Deactivation (Advanced Atkinson Tech Package)

EPA relies heavily on higher compression ratio, naturally aspirated gasoline engines, operating on the Atkinson thermodynamic cycle (ATK2) for its modeled technology path for MY2025 compliance. Furthermore, this technology is largely used in combination with CEGR and cylinder deactivation (DEAC) technologies.[89] Benefits of this technology pathway are modeled at over a 15% efficiency improvement, on average, relative to the "null" vehicle used by the LPM.

EPA's modeled effectiveness values for the ATK2+CEGR+DEAC pathway (Advanced Atkinson Tech Package) are seriously overestimated. The Alliance has identified the following issues, (described in further detail below): base engine fuel consumption maps are optimistic; practical limitations for CEGR to limit engine knock are not full considered; there is an over-optimistic reliance on the availability of cylinder deactivation at unrealistic speed / load operating points; and the impact of 91 RON market and certification test fuels was not taken into account.

Furthermore, EPA's projected penetration rates are aggressive given that many manufacturers have already started (or are well on their way) down different technology paths, such as turbocharging and downsizing and given the limited time available to develop the technology package described before the MY2022-2025 period.

The Alliance recommends the following:

1. Do not utilize the Advanced Atkinson Tech Package in future analyses until the modeled engine maps (which fundamentally determine technology effectiveness of this package in the Draft TAR) are fully validated using 91 RON fuel (Tier 3 emissions certification test fuel) by dynamometer test results.

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[89] 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, (EPA-420-D-16-900, July 2016) at ES-10, Table ES-3 and OEMGA model outputs supporting Table 12.33 at 12-29. Higher compression ratio, naturally aspirated Atkinson cycle gasoline engines are modeled at 44% penetration. Approximately 90% of those engines are packaged in combination with cylinder deactivation and CEGR. (Derived from OMEGA model output underlying Draft TAR Table 12.33.)

2. Develop an accurate high-fidelity engine fueling map for the benchmark MY2014 Mazda SkyActiv. Specifically, develop both a dynamometer test data for low load / rpm brake specific fuel consumption (BSFC) data points and a dynamometer test data using 91 RON fuel.

3. Use two fuel surfaces in the vehicle level modeling tools (ALPHA and Autonomie) to accurately model cylinder deactivation use.

4. Consider appropriate penetration caps in the OMEGA and Volpe models to account for the technology pathways that manufacturers are already implementing, and the time necessary to develop a new family of engines based on ATK2 technology as it relates to the timeframe of the rules under discussion.

The Alliance welcomes interaction between the Agencies' and automakers' technical staff to discuss these issues in further detail for the purposes of developing a robust, accurate estimate of the benefits of this potential future technology package to which all stakeholders can agree.

The Modeled Effectiveness of the Advanced Atkinson Tech Package Is Likely Overestimated Due to Multiple Flaws in the Benchmarking and Modeling Approaches Taken by EPA

EPA started the estimate of future Atkinson engine technology benefit with the benchmarking of the United States market version of the 2.0 liter Mazda SkyActiv engine (13:1 CR without CEGR and without cylinder deactivation),[90] as detailed in SAE paper 2016-01-0565.[91] This data was then used to correlate a GT-POWER model. This GT-POWER model was then used to project the operation of a future the engine with the following key changes and additions:

- Increased compression ratio from 13:1 to 14:1 and assumed (without validation) operability on 91 RON fuel
- CEGR
- Cylinder deactivation

A comparison was made between the engine map generated by EPA's benchmarked production 2.0 liter Mazda SkyActiv baseline fuel map that used 96+ RON fuel[92] and an engine map generated by USCAR that benchmarked a similar vintage 2.0 liter SkyActiv engine, but using 91

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[90] This is an Atkinson cycle engine in a non-hybrid application, i.e. the EPA "ATK2" technology prior to the addition of CEGR and cylinder deactivation.

[91] 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, doi:10.4271/2016-01-0565.

[92] Advanced Light-Duty Powertrain and Hybrid Analysis (ALPHA) Tool, ALPHA v2.0 Simulation Samples, "engine_2014_mazda_skyactiv_US_201_93AKI_v2." U.S. Environmental Protection Agency. Accessed September 26, 2016. https://www3.epa.gov/otaq/climate/documents/alpha-simulation-samples.zip.

RON fuel.[93] The EPA benchmark fuel map has some areas of concern that call into question its use as a baseline for further theoretical additions of technology. The Alliance would welcome the opportunity to work with EPA to understand the discrepancy between the data sets and help rectify any potential issues.

The differences between the USCAR and EPA fuel maps described in the paragraph above are shown in Figure B-1 below. The green areas in the plot (where EPA projects lower fuel consumption than USCAR) are due to knock limit improvements associated with EPA's use of premium fuel for benchmarking. The octane advantage can clearly be seen in the comparison, and results in engine fuel map benefits that cannot be achieved with market grade regular and Tier 3 certification test fuels.

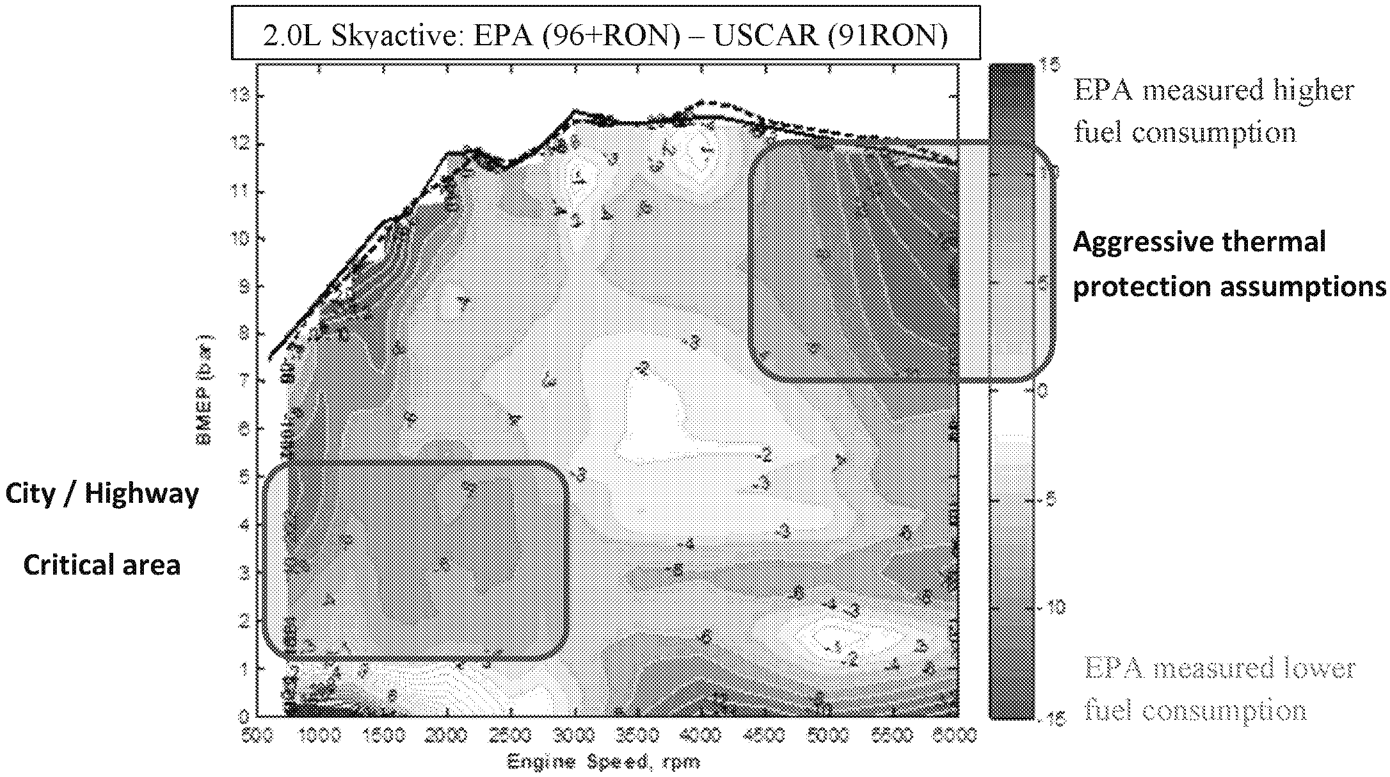

Figure B-1: Comparison of Mazda SkyActiv 2.0 L - EPA Data (96+ RON) vs. USCAR Data (91 RON)

At the speed load points used during the certification cycles, the use of high octane fuel provides a significant benefit relative to the results using 91 RON fuel. Manufacturers cannot realize this benefit as they must protect for on-road operation with 91 RON, and certify with the same.

[93] Courtesy of USCAR.

In developing the engine map used by ALPHA to estimate the benefits of the Advanced Atkinson Tech Package, EPA used the GT-POWER simulation modeling tool. This is an accepted approach by the industry to evaluate new technologies. However, the industry's approach to using GT-POWER results requires extensive calibration and validation, and there are widely recognized limitations that must be taken into account. These include, as mentioned in Appendix A, limitations such as the accuracy of predicting knock, predicting combustion stability, and the ability to accurately reflect control limitations such as cam slew rates.

The GT-POWER modeled benefits of the Advanced Atkinson Tech Package have not been verified by manufacturers or the Agencies, even in an engine dynamometer setting, let alone in a production vehicle designed to meet all regulatory and customer driven requirements. In SAE Paper 2016-01-0565, EPA noted, "[the] BSFC map [of the ATK2 engine] at 14:1 CR [with cooled EGR and cylinder deactivation] could not be validated with engine dynamometer operation, even with use of 96 RON E0 fuel, due to the onset of knock." This result alone suggests EPA's approach is not viable without significant further study and development.

Furthermore, in May 2016, when EPA staff presented the results of their research described in SAE paper 2016-01-0565[94] to a group of advanced engine design and development experts from General Motors, Ford Motor Company and FCA US LLC, plus representatives and engine system experts from the Department of Energy, and four national laboratories (Argonne, Oak Ridge, Sandia, and Pacific Northwest), the industry representatives noted multiple issues that, in their opinion, would make the modeling results "not accurate enough for reference" in the MTE. Issues identified included:[95]

- The model results and experimental results do not match within a range suitable for deriving fuel efficiency benefits over wide range of operations (more specifically, drive cycles).
- There are perceived flaws in some of the qualitative assumptions (over quantitative) used as inputs in the modeling and subsequent validation of the results. The team requested that the complete assumptions for the model be made available for further study.
- Engine performance effects due to realistic limitations associated with knock, Ccooled EGR heat rejection, and effective compression ratio were not considered in detail but will impact overall efficiency gains significantly.

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[94] 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, doi:10.4271/2016-01-0565.
[95] Minutes, United States Council for Automotive Research Advanced Combustion and Emission Control Tech Team Meeting. May 12, 2016. Courtesy of USCAR.

Additionally, it appears that there was a serious clerical error in translating the GT-POWER full load torque data to ALPHA which was then carried into the LPM's calibration. We note that in the SAE paper 2016-01-0565[96] the GT-POWER model correctly limited the full load torque of the engine due to knock onset. However, it is not clear that this significant reduction in torque was translated to the Advanced Atkinson Tech Package used in ALPHA simulation work which was subsequently used to calibrate the LPM model. This error incorrectly leads to exercising downsizing options because the performance metrics could theoretically be met with the torque that should have been limited as shown in SAE paper 2016-01-0565.[97] The net result is a large overestimation of the benefit with the Advanced Atkinson Tech Package. The modeled performance would be further degraded if correct CEGR assumptions were used as discussed below. Figure B-2 compares the two torque curves, baseline Atkinson, and the Advanced Atkinson Tech Package.

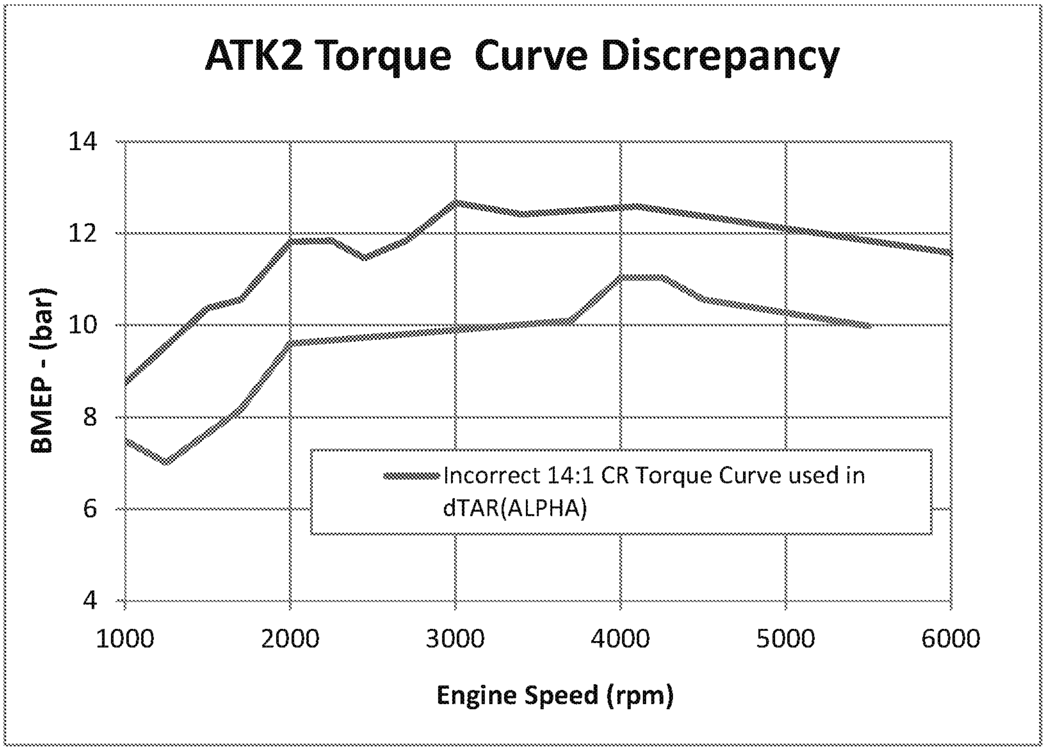

Figure B-2: ATK2 Torque Curve Discrepancy between SAE and ALPHA[98,99]

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[96] 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, doi:10.4271/2016-01-0565.

[97] *Id.*

[98] Process for Generating Engine Fuel Consumption Map (Mazda SKYACTIV 2.0L engine using Tier 2 fuel). U.S. Environmental Protection Agency. Accessed September 26, 2016. https://www3.epa.gov/otaq/climate/documents/2014-mazda-2.0l-skyactiv-13-1-engine-tier-2-fuel-mapping-process-2016-06-20.pdf

There are additional technical concerns with the Advanced Atkinson Tech Package engine map that was part of the Draft TAR ALPHA model sample release. Additional issues which make the engine maps developed from this work questionable include:

- A study of the map and the findings of SAE paper 2016-01-0565[100] suggest a number of questionable assumptions concerning cylinder deactivation, knock, and the late intake valve closing (LIVC) operation.
- Assumptions were vastly simplified with a number of controls issues surrounding CEGR use which would mitigate much of the final benefit if properly taken into account.
- The Alliance also has concerns with the "in good agreement" model correlation statements cited in SAE paper 2016-01-0565[101] when the data in the paper shows that the correlation is not within 5% in many of the critical operating areas.

Other prominent issues that should be considered by EPA are listed below:

- A key element of the Advanced Atkinson Tech Package is the long 4-2-1 exhaust manifold, which allows the engine to get all of the exhaust out of each cylinder without pressure pulse interference. However, the long exhaust manifold also moves the catalyst farther downstream of the cylinder head, making it hard to light off quickly to reduce emissions during startup. Additionally, long exhaust manifolds, by definition, prevent a close coupled catalyst strategy, ultimately requiring additional fuel to light off the catalyst during startup.
- The increased heat rejection loading associated with the Advanced Atkinson Tech Package will increase accessory loads.
- The addition of CEGR also impacts implementation of vehicle demand energy improvement technologies such as active grill shutters.
- The complexity in implementing Advanced Atkinson Tech Package potentially increases durability concerns.

The EPA Modeled Advanced Atkinson Technology Package Penetration Rates Are Not Feasible

For the Draft TAR, EPA modeled that almost every automaker (except Tesla which only produces battery electric vehicles) will adopt the Advanced Atkinson Tech Package by MY2025 (Figure B-3), and that a number of manufacturers will exceed 50% penetration of this technology

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[99] 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, doi:10.4271/2016-01-0565.
[100] *Id.*
[101] *Id.*

package. Even though Atkinson cycle engines in non-hybrid applications have begun to appear in the marketplace, the Alliance does not believe that this high technology penetration is likely or feasible. Even more questionable is the estimate that 40% of the fleet will have the Advanced Atkinson Tech Package, which has yet to be realized in any production engine.

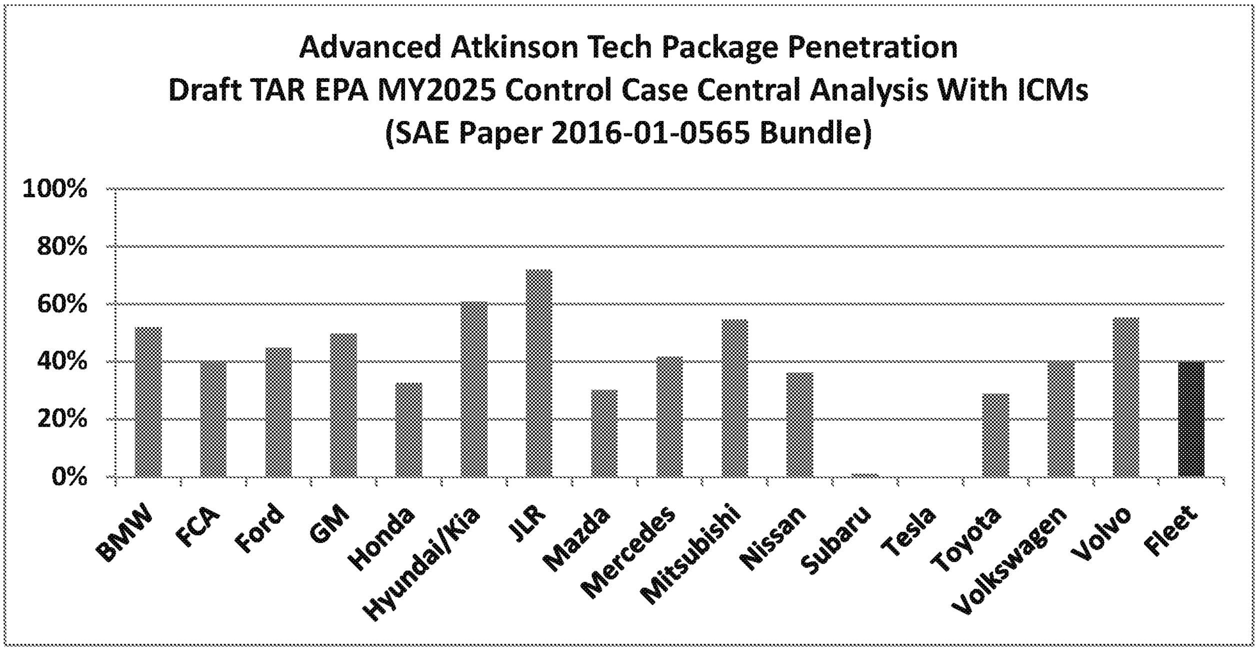

Figure B-3: MY 2025 Advanced Atkinson Tech Package Penetrations in the EPA Control Case Central Analysis with ICMs[102]

The introduction of new engine technology requires many years, as is demonstrated by data in the Fuel Economy Trends Report.[103] For example, gasoline direct injection technology which represented 2.3% of production in MY2008 grew to just over 45%of expected production for MY2015. It took seven years for a relatively mature technology to reach 45% market penetration. In the case of the Advanced Atkinson Tech Package, even more time will likely be required given that this technology package (as modeled by EPA) has not yet been successfully demonstrated, even in a laboratory.

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[102] Optimization Model for reducing Emissions of Greenhouse gases from Automobiles (OMEGA). OMEGA pre-processor, Technology cost development, and Input/Output files used in the Draft TAR analysis. OMEGA output files for the MY2025 Control Case Central Analysis. U.S. Environmental Protection Agency. Accessed September 26, 2016. https://www3.epa.gov/otaq/climate/documents/omega-tar2016.zip.

[103] "Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 Through 2015." Environmental Protection Agency. EPA-420-R-15-016. 2015. Accessed September 17, 2016. https://www3.epa.gov/fueleconomy/fetrends/1975-2015/420r15016.pdf.

Furthermore, it is not reasonable to assume that automakers which have already invested resources and are in the middle of executing strategies based on non-Atkinson technologies (e.g. turbocharging and downsizing) will change strategies completely, or add another major powertrain technology pathway. The additional cost and resource required to execute such a major shift will preclude this option. We commend NHTSA for recognizing this practical resources-based constraint in limiting the application of the Advanced Atkinson Tech Package in the Volpe model.

Additionally, even if automakers choose to pursue an Atkinson cycle based pathway, it is doubtful that virtually all automakers could reach the projected levels in the MY2022-2025 timeframe. There are too few new program opportunities and product plans are likely to already be final for the next several years.

Finally, the level of vehicle integration required to include the elements of the Advanced Atkinson Tech Package pose additional implementation challenges. Not all existing vehicle architectures lend themselves to packaging of the 4-2-1 exhaust manifold. For those vehicles, this requires a revamp of vehicle architectures to integrate this manifold, which significantly increases the implementation timeframe. There are also packaging concerns with CEGR due to the upsizing required for CEGR components for some vehicle segments.

Downsized / Turbocharged Engines

The Alliance agrees with the Agencies' approach of no longer assuming downsizing and turbocharging to the 27 bar level in the Draft TAR. However, we are still concerned that the modeled effectiveness values for turbocharged downsized engines are optimistic. The following key issues are identified and should be corrected. Downstream modeling efforts affected by these changes should also be reassessed prior to further use in the MTE.

- The efficiency of the engine maps used as EPA's basis for boosted engines is too optimistic; use of high octane fuel (instead of the lower octane fuel required for Tier 3 emission testing) and broad over-optimistic friction reduction assumptions contribute to efficiencies we believe are not attainable in practice.
- Both Agencies' effectiveness assumptions are based on 96+ RON test fuel, not the future CAFE/GHG fuel (91 RON Tier 3 / LEV III fuel). However, the Alliance does appreciate NHTSA's assurance that any subsequent testing will use fuel with the appropriate octane level.
- The degree of downsizing posited by the Agencies relies on infinite displacement engines "on the shelf" for automakers and ignores performance and drivability constraints that automakers have to evaluate when considering downsizing.

It is our understanding that the engine fuel maps for downsized, turbocharged gasoline engines were developed by Ricardo for use by the EPA.[104] The Alliance requests that EPA outline its rationale for using an experimental single cylinder engine map as the basis of their analysis of turbocharged downsizing technology rather than using actual production engines that were benchmarked by EPA (Ford 1.6 L Ecoboost and Ford 2.7 L Ecoboost). The Ricardo maps, unchanged since the 2012 FRM, have multiple technical issues which ultimately result in over-optimistic projections of the benefits of this technology.

We believe these fuel maps are based on data with high octane fuel as detailed in the document released during the Draft TAR titled "Process for Generating Engine Fuel Consumption Map: Ricardo Cooled EGR Boost 24-bar Standard car Engine Tier2 Fuel."[105] The Alliance believes that maps should be developed using the default Tier 3 emissions certification test fuel with 91 RON and these maps should be the basis of EPA's analysis. EPA regulations require this low octane fuel be used for FE and GHG testing in the MY2022-2025 timeframe for vehicles that do not require premium fuel. EPA's use of engine maps developed using high octane fuel for boosted downsized engine technology in the Draft TAR has resulted in overestimation of effectiveness.

The lower octane of the Tier 3 test fuel degrades efficiency at mid- and high-load conditions because of the need to retard spark due to the onset of knock. Higher-load operation is particularly important because downsized engines will operate more frequently at higher loads relative to larger displacement engines.

Figure B-4 demonstrates all the operating speed / load points over the city and highway test cycles from a Ford F150 3.5L GTDI (EcoBoost) engine. The limitations of regular grade (91 RON) fuel are illustrated by the points above the green mean best torque (MBT) line. To prevent engine damage for these operating points, the combustion phasing is delayed at the expense of combustion efficiency.

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[104] 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, (EPA-420-D-16-900, July 2016) at 5-283.

[105] Process for Generating Engine Fuel Consumption Map (Ricardo Cooled EGR Boost 24-bar Standard Car Engine Tier 2 Fuel). U.S. Environmental Protection Agency. Accessed September 26, 2016. https://www3.epa.gov/otaq/climate/documents/std-car-egrb-enginemapping-process-2016-06-20.pdf

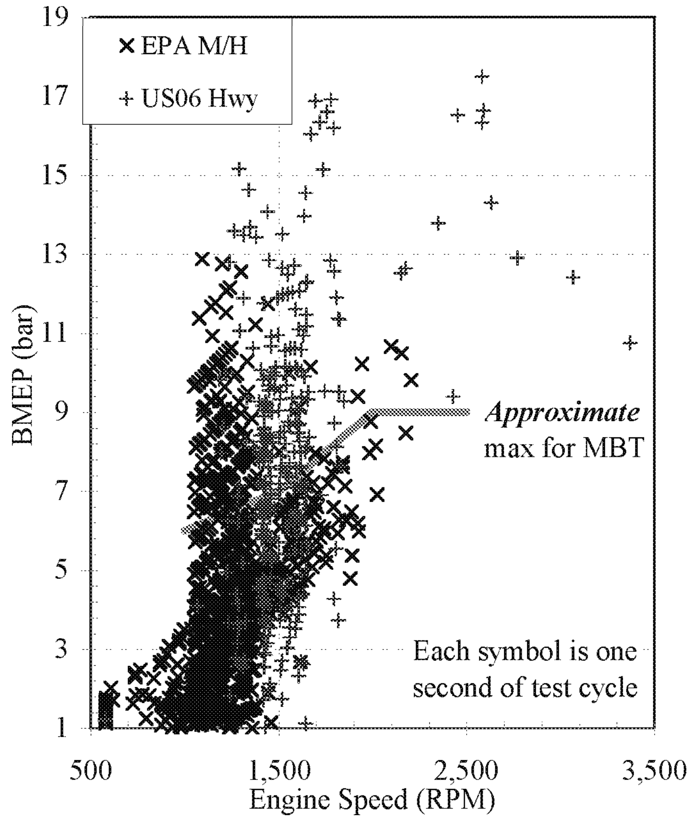

Figure B-4: Speed-Load Points for a Ford F150 3.5L GTDI (EcoBoost) Engine[106]

Fuel octane limitations are further demonstrated in Figure B-5 which shows large impacts on fuel consumption at high-load conditions. Note that with moderate downsizing, engine efficiency increases, but aggressive downsizing results in degraded efficiency. This is particularly important because in many cases the Agencies' downsizing assumptions appear to be based on maximizing the efficiency over city and highway test cycles while ignoring efficiency reduction during higher-load driving conditions (for example US06 and high-speed interstate driving conditions). Automakers must consider customer drivability and performance acceptance including high-load driving conditions when determining the appropriate level of downsizing, and cannot implement the level of downsizing based on analysis that is derived solely on operation during certification cycles. Using 91 RON fuel (e.g. Tier 3 fuel) there is no further CO_2 benefit below a displacement-over-mass ratio (D/M) of about 0.9. However, as shown by the 96 RON and 101 RON data in the figure below, the Agency assumptions based on higher-octane fuel would indicate that additional downsizing beyond 0.9 D/M still yields reductions in CO_2.

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[106] Leone, T., Olin, E., Anderson, J., Jung, H. et al., "Effects of Fuel Octane Rating and Ethanol Content on Knock, Fuel Economy, and CO_2 for a Turbocharged DI Engine," SAE Int. J. Fuels Lubr. 7(1):2014, doi:10.4271/2014-01-1228.

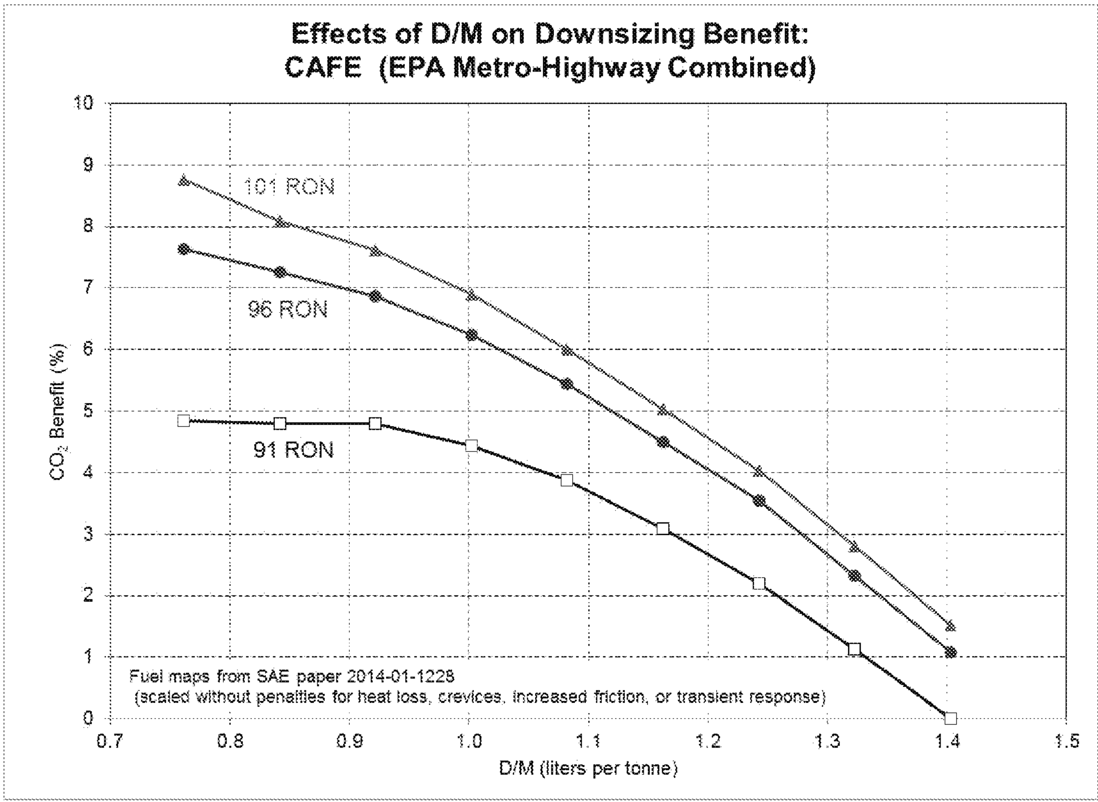

Figure B-5: Effects of D/M on Downsizing Benefit: CAFE Unadjusted Combined Fuel Economy[107]

Even more importantly, Figure B-6 below shows that overestimating the degree of downsizing will actually decrease fuel efficiency at higher loads (high-speed on-road driving, US06). This effect is amplified with higher octane fuels. The figure shows decreases in CO_2 benefit for engines with a D/M of 1.2 while using 91 RON fuel.

[107] Courtesy of Ford Motor Company. Based on fuel maps from SAE paper 2014-01-1228: Leone, T., Olin, E., Anderson, J., Jung, H. et al., "Effects of Fuel Octane Rating and Ethanol Content on Knock, Fuel Economy, and CO2 for a Turbocharged DI Engine," SAE Int. J. Fuels Lubr. 7(1):2014, doi:10.4271/2014-01-1228.

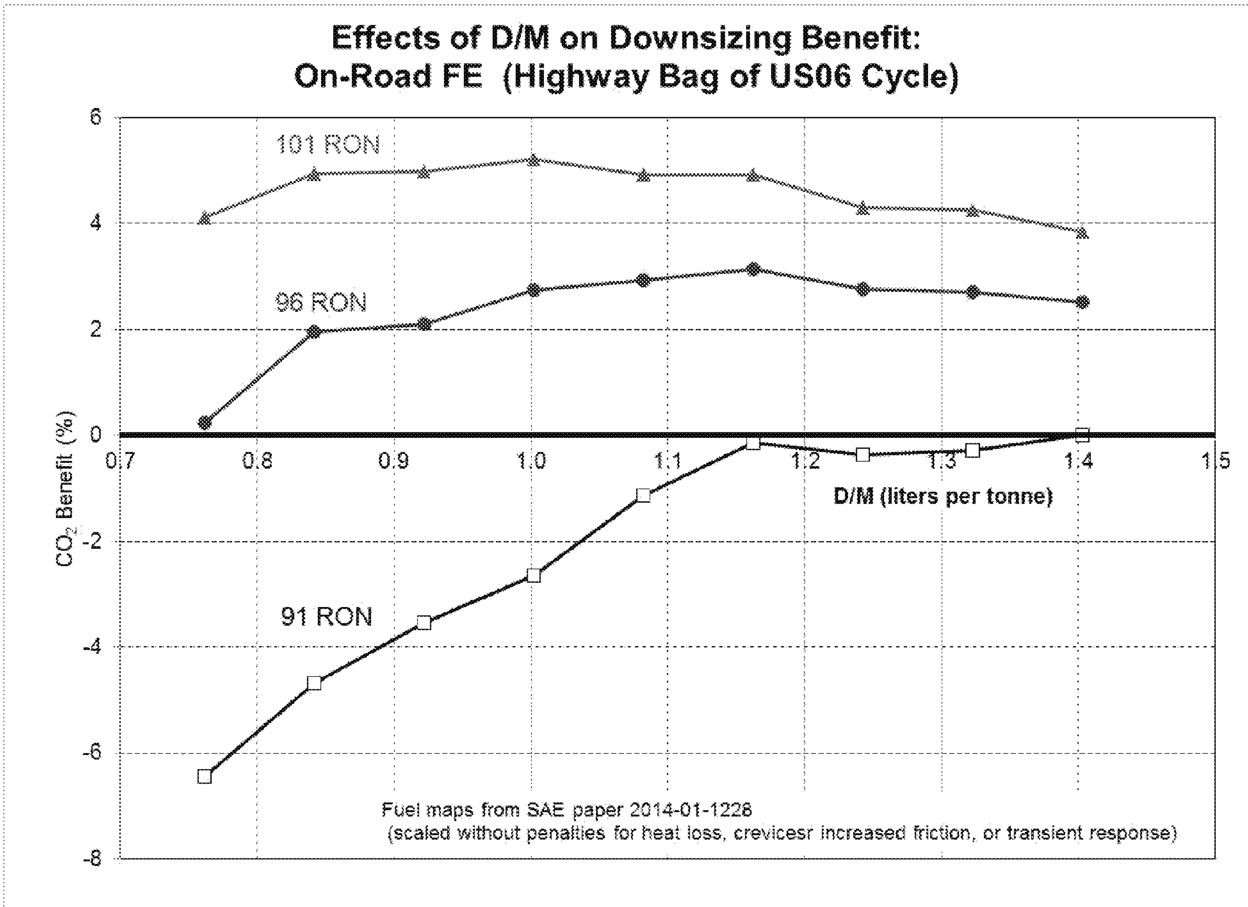

Figure B-6 Effects of D/M on Downsizing Benefit: On-Road Fuel Economy (Highway Bag of US06 Cycle)[108]

The Ricardo analysis assumes ~30 bar BMEP.[109] This is not feasible with 91 RON fuel, even with an advanced boosting system. The Agencies acknowledged this concern and lowered the BMEP from 27 to 24 bar in the Draft TAR. However, the levels of CEGR (+25%) assumed with this technology are not practical. The Alliance would welcome an opportunity to discuss this further to understand the assumptions behind the applicability of high levels of CEGR to 24 bar boosted systems.

Engine downsizing also has significant trade-offs and constraints that should have been fully considered, but were not, including:

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[108] *Id.*

[109] Process for Generating Engine Fuel Consumption Map (Ricardo Cooled EGR Boost 24-bar Standard Car Engine Tier 2 Fuel). U.S. Environmental Protection Agency. Accessed September 26, 2016. https://www3.epa.gov/otaq/climate/documents/std-car-egrb-enginemapping-process-2016-06-20.pdf.

- The Ricardo analysis assumed 3.5% benefit from improved engine friction, but downsizing increases cylinder pressures and thermo-mechanical loads, which will actually increase friction.
- There are additional loads such as higher oil pump capacity (for piston cooling jets, variable valve trains, turbochargers, etc.), larger bearings and crank pins, heavier pistons with increased ring tension, balance shafts to reduce NVH with reduced numbers of cylinders and greater cooling capacity.
- Ricardo's analysis increased heat transfer losses with downsizing (although the magnitude was not disclosed).[110] However, Ricardo's analysis did not account for increased crevice losses with downsizing, which are significant.[111,112]

Additional concerns with the underlying Ricardo work[113] include:

- Stoichiometric operation was assumed based on a paper by Schmuck-Soldan et al.,[114] which featured an engine with 9.2:1 CR and high octane (95 RON) fuel. The results of the paper were extrapolated to a 10.5 CR with lower octane (91 RON) fuel. The Ricardo analysis[115] did not properly account for US06 test cycle and on-road emissions / enrichment constraints, essentially increasing CR and reducing octane at the same time.
- Higher BMEP requires more than just higher boost pressure – high octane fuel is a key enabler.[116]

It is also not clear that the effect of CEGR requirements at full load were considered by Ricardo[117] when combustion phasing limits were evaluated. Full load combustion phasing *limits* the compression ratio, so cooled EGR would be required *at full load*. This is constrained by boost system capability, vehicle heat rejection capacity, compressor outlet temperature limits

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[110] *Id.*
[111] *See* Smith, P. and Cheng, W., "Assessing the Loss Mechanisms Associated with Engine Downsizing, Boosting and Compression Ratio Change," SAE Technical Paper 2013-01-0929, 2013, doi:10.4271/2013-01-0929.
[112] *See* Smith, P., Cheng, W., and Heywood, J., "Crevice Volume Effect on Spark Ignition Engine Efficiency," SAE Technical Paper 2014-01-2602, 2014, doi:10.4271/2014-01-2602.
[113] Process for Generating Engine Fuel Consumption Map (Ricardo Cooled EGR Boost 24-bar Standard Car Engine Tier 2 Fuel). U.S. Environmental Protection Agency. Accessed September 26, 2016. https://www3.epa.gov/otaq/climate/documents/std-car-egrb-enginemapping-process-2016-06-20.pdf.
[114] Schmuck-Soldan et al., "Two Stage Boosting of Spark Ignition Engines" (Internationales Wiener Motorensymposium 2011).
[115] Process for Generating Engine Fuel Consumption Map (Ricardo Cooled EGR Boost 24-bar Standard Car Engine Tier 2 Fuel). U.S. Environmental Protection Agency. Accessed September 26, 2016.
[116] Leone, T., Olin, E., Anderson, J., Jung, H. et al., "Effects of Fuel Octane Rating and Ethanol Content on Knock, Fuel Economy, and CO2 for a Turbocharged DI Engine," SAE Int. J. Fuels Lubr. 7(1):2014, doi:10.4271/2014-01-1228.
[117] Process for Generating Engine Fuel Consumption Map (Ricardo Cooled EGR Boost 24-bar Standard Car Engine Tier 2 Fuel). U.S. Environmental Protection Agency. Accessed September 26, 2016.

(due to coking), engine transient response, and component sizing and cost. If boost is used for EGR, it limits the maximum BMEP and downsizing.

For further information, please see the attached "Limitations of Ricardo Fuel Economy Analysis of Downsizing" presentation.[118]

Industry "Rightsizing" of Downsized Turbocharged Engines

The direction of automakers has been towards moderate downsizing of boosted engines. Early examples of more aggressive downsizing, such as the Ford 2.0L Ecoboost engine and Audi 1.8L, were met with low customer acceptance and were subsequently replaced with more appropriately downsized engines (2.3L in the case of Ford, and 2.0L in the case of Audi[119]).

Summary

Downsizing is constrained by many factors including:

- Regulatory compliance (city and highway cycles) is not improved with more downsizing beyond a certain point when designing for 91 RON fuel.
- Efficiency during on-road high load operation does not improve beyond a certain level of downsizing, and can actually decrease if downsizing is too aggressive. This effect is further amplified with the use of regular grade octane fuel.
- Higher BMEP combustion phasing requires lower compression ratio and / or high octane fuel.
- Enrichment and emissions control for on-road high speed / high acceleration will negatively impact downsizing efforts.
- Transient response limitations, including shift schedule effects will negatively impact the benefits of downsizing.

The Alliance believes that the benefits of turbocharging and downsizing were overestimated by EPA primarily because of the following reasons:

- Downsizing benefits were extrapolated beyond reasonable D/M ratios.
- Fuel maps were not developed with future compliance test fuels and market fuels (Tier 3 91 RON).
- The modeled engine maps did not account for crevice losses, higher friction, and lower compression ratio.

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[118] Attached as Attachment 7. Presentation courtesy of Ford Motor Company.

[119] *See* Audi presentation from Internationales Wiener Motorensymposium 2015, which describes the 1.8L engine being "rightsized" back to 2.0L.

- Benefits of CEGR were overestimated given implementation constraints such as higher accessory loads and heat rejection.
- It appears that the effectiveness levels of cylinder deactivation, when applied to downsized boosted engine technology with CEGR, are too high.

The Alliance would welcome an opportunity to discuss this further to understand the assumptions used.

Advanced Transmissions

The Alliance disagrees with the Agencies' treatment of transmissions in Chapter 5 of the Draft TAR. The issues are summarized below:

- Fundamentally different transmission technologies, such as continuously variable transmissions (CVTs), dual clutch transmissions (DCTs) and planetary) were lumped into bundles and were assigned identical efficiencies by the EPA.
- We do not agree with EPA's estimates of the absolute effectiveness of TRX11 and TRX21.
- We do not agree with the level of benefits cited by EPA in adopting high efficiency gearboxes (HEG2) elements on TRX11 and TRX21 transmissions.
- The relative improvements expected by upgrading transmissions from TRX11 to TRX22 are overstated.

Transmissions continue to provide a critical source for continuing improvements in CO_2 reduction and improved FE. As noted in the Draft TAR, automakers have already achieved significant penetration rates of advanced transmissions into the fleet and have increased gear count from 4-, 5-, and 6-speeds up to 7-, 8-, 9- and even 10-speeds. While other transmission technologies such as CVTs are also experiencing strong growth, we expect conventional automatic transmissions to remain the primary transmission technologies through MY2025 and beyond.

Moving forward, the primary focus for additional improvements to transmissions will continue to include the balance of FE optimization and meeting the full array of vehicle functional requirements and customer expectations. It is important that the Agencies remain sensitive to customer feedback regarding shift comfort for transmissions. Dual clutch transmissions, once expected by the 2012 FRM to become the leading technology, have generally failed to achieve market acceptance in the United States due to ongoing customer concerns with feel and comfort. Early generation 9-speed transmissions experienced significant product launch issues due to customer satisfaction with shift feel. Even newer generation CVTs have had to adopt features to improve driving experience, or in some cases even mimic the feel of an automatic transmission, in order to meet customer expectations. While many of these issues have since been improved, any new customer issues that appear may require alterations that could detract from the expected FE benefit.

Significant investments have been made to continue the development and improvement of 8+ gear wide ratio transmissions. Current generation wide ratio transmission architectures are generally expected to carry through MY2025 and include many of the following technical features:

- Improving efficiency through bearing, seal, oil level, and oil distribution optimization.
- Torque converter technology has changed to reduce lock-up speeds and improve NVH.
- Improved matching of engine and electrified propulsion system technologies to the transmission portfolio.

The effectiveness values attributed to the transmissions used by EPA are overly optimistic compared to the actual benefit provided by vehicles with wide ratio transmissions introduced by the automakers. Additionally, the Alliance also did not find evidence that suggests that the Agencies accounted for packaging these transmissions in existing or future vehicle architectures.

Estimates of the Absolute Effectiveness of TRX11 and TRX21

The Agencies estimated the absolute effectiveness of TRX11 transmissions based on a GM six-speed transmission from the 2013 Malibu.[120] Relative to a null transmission on a null engine, the Agencies estimated that TRX11 transmissions deliver 5.5-7.5% improvement depending on vehicle size.[121] The Alliance believes that these effectiveness improvement estimates by the Agencies are unobtainable.

We cannot quantify which technologies are overestimated because of EPA's binning methodology, which does not recognize unique efficiencies of different transmission technologies. Going forward, the Alliance recommends EPA harmonize with NHTSA on this point. The Alliance would welcome the opportunity to work with EPA to provide a technically accurate way of modeling the benefit of vastly different and emerging transmission technologies.

We also recommend that EPA abandon the confusing nomenclature adopted in the Draft TAR and specifically identify the transmissions and the unique technology associated with the transmissions.

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[120] 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, (EPA-420-D-16-900, July 2016) at 5-297.
[121] *Id.* at 5-298.

Marginal Improvements Due to HEG2

The EPA expects that transmissions mapped to both the TRX11 and TRX21 designations "can be improved to a level that would bring the transmission effectiveness to the efficiency level" of the TRX12 or TRX22. Manufacturers anticipate challenges in attempting to implement those efficiency improvements.

The EPA estimates average marginal improvements in effectiveness due to adoption of high efficiency gearbox level 2 technologies (HEG2) of 4.2 percentage points for TRX11/12, and 2.7 percentage points for TRX21/22.[122] The Alliance disagrees with these estimates primarily because this loss area has already been in development and optimization for several decades (many current designs of existing gears are already at high efficiency). Additionally, the theoretical efficiency gains are offset by automakers' needs to balance efficiency against noise, durability, and packaging.

The EPA's reliance on the ALPHA model and information in SAE papers to model the effect of adding HEG2 to TRX21[123] is particularly problematic. For example, FCA US LLC (FCA) recently introduced an upgraded 8-speed rear-wheel drive transmission. Upgrades to this transmission include: the introduction of clutch separator springs to reduce clutch drag, a reduction in oil pressure, and improved hydraulic efficiency in the solenoid and valve body.

Some of these elements are similar to the HEG2 elements referred to in the Draft TAR. The CO_2 benefit with these actions was approximately 0.8% unadjusted combined FE. We acknowledge that the gear ratios did not change between first and second generation transmissions, and that this is contrary to EPA's expectation with HEG2 transmissions. However, FCA has indicated that modeling using wider spread ratios reveals that there is no improvement in CO_2 once the transmission is adjusted to adequately protect for shift "busyness" and feel.

As the Alliance described in earlier comments, a number of shortcomings undermine the ALPHA model and its outputs. The process in which individual improvements are picked from SAE papers suffer from similar issues, where many small errors across analyses compound into a significant disconnect from manufacturer expectations.

Improvements Due to Deployment of TRX22 Relative to TRX11

In upgrading transmissions from TRX11 to TRX22, the Agencies believe that a "9.7% improvement in effectiveness is achievable."[124] Supporting this view, the EPA contends that

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[122] *Id.* at 5-298.
[123] *Id.* at 5-298.
[124] *Id.* at 5-298.

"most transmissions can gain 6-10 percent from efficiency improvements alone."[125] While such improvements may be theoretically possible, improvements in efficiency from upgrades more typically fall in the range of 1%-2%. Overall, manufacturers expect that moving from TRX11 to TRX22 will deliver effectiveness improvements in that range of 1%-2% due to relentless market-driven requirements for durability, noise, and packaging.

Transmission Modeling in ALPHA

EPA's standard car ALPHA simulation samples include two 6-speed to 8-speed HEG1 transmission walks, one using GM Ecotec and the other with Mazda SkyActiv engine, each showing 9.0% and 8.6% $C0_2$ reduction effectiveness, respectively. Industry modeling indicates that a maximum of 4% effectiveness can be achieved from 6-speed to 8-speed HEG1 transmission upgrade. The 4.6%-5.0% discrepancy can be attributed to the four bins listed below based on modeling work done using both EPA's ALPHA tool and verifying the results with industry's modeling tools. The four bins are: lock-up assumptions, torque converter lock-up efficiency, engine downsizing methodology, and transmission models and modeling. Some of the issues identified during this verification are listed below.

EPA uses third gear lockup for both 6-speed and 8-speed transmissions. This assumption gives the 8-speed an advantage since it allows the 8-speed transmission to lock up at lower vehicle speed. It should be noted that EPA's 8-speed model has 4th gear ratio about equal to the 6-speed transmission's 3rd gear ratio. The proper assumption here is 4th gear lock-up for the 8-speed transmission. This accounts for an estimated for 0.3%-0.8% of the effectiveness discrepancy.

ALPHA transmission walks have torque converter lock-up efficiency modeled as 98.5% for 6-speed and 99.5% for 8-speed. This assumption is invalid unless this indicates next generation torque converter technology with 8-speed transmissions. In the HEG1 6-speed to HEG1 8-speed walk done by EPA the high efficiency assumption is misleading and instead should use common torque converter efficiency. Using the common 98.5% converter lock-up efficiency in ALPHA simulation shows that 0.6% of the effectiveness discrepancy is due to this assumption.

In the Draft TAR, the EPA methodology uses matching 0-30 mph and 0-60 mph times in vehicle powertrain configuration walks. For the 6-speed to 8-speed ALPHA transmission walk, EPA downsized the engine by approximately 10% and shows that replacing 6-speed with 8-speed should result in equal performance even with the smaller engine. This methodology, however, fails to consider other important vehicle attributes that are strictly related to engine's power capability. For example, industry estimates that this would degrade a standard vehicle's top gear 75 mph grade-ability by more than 10%, thus effectively taking the downsizing option away.

[125] *Id.* at 5-298.

Keeping the same engine, the ALPHA transmission walk shows that this methodology accounts for 1.4%-2.0% of the effectiveness discrepancy.

Lastly, industry modelers applied the baseline 6-speed (GM 6T40) and 8-speed data (ZF 8HP45/RE) in ALPHA and found that 1.0%-1.8% of the discrepancy is due to differences in transmission models and modeling. To verify EPA's transmission modeling approach, the industry would like to request that EPA clarify the modeling assumptions specifically related to transmission inertia modeling and how the conversion of rear wheel drive (RWD) to front wheel drive (FWD) of FCA's 8HP45 transmission was modeled.

Based on the concerns on EPA's transmission modeling, the industry recommends that EPA take the following actions:

- Use a common ratio lockup in same generation (HEG1) transmissions.
- Use common lockup efficiencies in the same generation (HEG1) transmissions.
- Add grade-ability metrics. In general, we recommend that EPA recognize all needed performance metrics in its analysis to ensure commercially saleable packages.

Additionally, we have questions on the following EPA transmission modeling assumptions:

- Why do the 6-speed transmissions have common gear inertias?
- Why are 8HP45 transmission gear inertias so small?
- What do the input and output inertias represent?
- Can EPA provide a detailed explanation on how they modeled the 8HP45 RWD to FWD data conversion?
- What is included in the HEG2 package?
- Does the following list of enablers complete EPA's assumptions for HEG2 package, and what effectiveness values are assigned to each of these enablers?
  - 2nd gear lockup
  - Lock-up efficiency improvement
  - Spin loss reduction
  - Pump loss reduction
  - Gearbox ratio optimization with increased span (8.7 span 8HP)

For further details of this analysis and the specific quantitative analysis, please see the attached presentation at Attachment 8.

Packaging Concerns

The Alliance did not find evidence that suggests that the Agencies considered packaging of these transmissions in existing or future vehicle architectures. Packaging is challenging, particularly for FWD transmissions which have the final drives inside the transmissions. In general, RWD transmissions tend to be long and smaller in diameter while FWD transmissions tend to be shorter and have a large diameter. In order to take a RWD architecture and put it into a FWD vehicle (as was assumed in EPA's conversion of the FCA 8HP45 RWD transmission to a FWD architecture), manufacturers must double stack the clutches radially, which leads to larger diameter clutches. This adds significantly to spin losses because (spin losses scale to the cube of radius. Additionally, the churning losses are relatively more in FWD transmissions as compared to RWD transmissions, as the clutches are immersed deeper in the oil. EPA should have accounted for these packaging constraints and trade-offs when projecting efficiencies for transmissions.

CVT Transmissions

The Agencies expect large efficiency improvements for CVT transmissions, increasing from 85% efficient to as much as 94% efficient in 2025. The EPA also expects that vehicles currently operating with CVT transmissions can increase to TRX21 with an accompanying 6% improvement in effectiveness.[126] However, the Alliance foresees much smaller improvements from upgrades to CVT transmissions. The assumption that CVTs currently operate at 85% efficiency is proper, but the method for improvement assumed by the Agencies is not described. CVTs already include the technologies listed to improve efficiency generally associated with TRX21. Clamping load is a significant requirement for CVT design and durability. A single slip can damage the CVT enough to require replacement of the entire CVT, and that need for reliability and warranty on behalf of the customer could limit the ability to substantially improve losses of the CVT.

48V Mild Hybrid

There are three main concerns regarding the Agencies' assumptions for mild hybrid technology: effectiveness, cost, and market penetration. The Agencies have presented very different interpretations of the costs, effectiveness, and market penetrations of mild hybrid technology both from each other, and from the 2012 FRM. In 2012, the Agencies based their cost and effectiveness values on a teardown study performed by FEV GmbH for EPA and battery costs from Argonne National Laboratory's (ANL) BatPaC model.[127] The 2012 FRM fleet projections relied heavily on the use of mild hybrids for fleet compliance and assumed that for MY2025 26% of the fleet would need this technology to comply (and up to 49% for certain manufacturers). Since 2012, the Agencies have not completed any further teardown studies on this technology, which has also not yet achieved a significant market share as predicted, but appear to have worked closely with suppliers to update the cost and effectiveness values. As a result, the Draft TAR, shows a significant decrease in the projected cost of this technology and increased effectiveness. The Agencies continue to view mild hybrids as a technology integral to compliance and now predict 18% of the fleet will need mild hybrid technology, while some

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[126] Id. at 5-299.
[127] 77 Fed. Reg. 62966 (Oct. 15, 2012).

manufacturers will now require this technology on nearly 75% of their fleet.[128] Whether or not mild hybrid technology sees high market penetration in the future depends not only on customer acceptance, but also on whether or not the Agencies properly understand and credit this technology.

Effectiveness and Cost

In 2012, EPA and NHTSA considered the cost and benefit of high voltage mild hybrid technology. In the Draft TAR, two different configurations of mild hybrid systems are now being considered by the Agencies: 48V Belt Integrated Starter Generator systems (BISG) and Crank Integrated Starter Generator systems (CISG). BISG systems typically have lower electric machine power (and therefore have lower effectiveness) and are less costly than CISG. In its analysis, EPA only considered BISG as a technology option, while NHTSA considered both BISG and CISG. In general, the Agencies comment that the new 48V systems have a more favorable cost-versus-effectiveness trade-off when compared to 115V systems. While there is some cost savings associated with stepping down the voltage from 115V to 48V, in general, the Alliance believes the Agencies are still greatly underestimating the cost of both BISG and CISG systems.

The Alliance attempted to draw a direct comparison of the Agencies' costs and effectiveness estimates to understand how each technology was used in the separate modeling work done by each Agency. In some cases, not all of the information was available in the Draft TAR, but the effort was made to directly compare the mild hybrid assumptions using the following assumptions:

1. The cost and effectiveness of improved accessories "IACC1, IACC2" were included.
2. The cost and effectiveness of electric power steering "EPS" were excluded.

Tables B-1 and B-2 below show a comparison of the assumptions used by the Agencies for the BISG system for both a standard passenger car and truck.

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[128] 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, (EPA-420-D-16-900, July 2016) at 12-29, Table 12.33.

Table B-1: BISG Medium/Standard Car Comparison[129]

	Effectiveness	Electric Machine kW	Direct Manufacturing Cost	
			MY2017	MY2025
NHTSA	12.9%	7 kW	$917	$717
EPA	9.4%	12 kW	$704	$565

Table B-2: BISG Truck Comparison[129]

	Effectiveness	Electric Machine kW	Direct Manufacturing Cost	
			MY2017	MY2025
NHTSA	10.9%	Not provided	$1,181	$924
EPA	7.1%	12 kW	$704	$565

In 2012, the Agencies used an effectiveness value of 7.3% for "high voltage" mild hybrids, Table B-1 and B-2 show a significant increase in effectiveness in the Draft TAR. In comparing Tables B-1 and B-2, significant differences in the EPA and NHTSA Draft TAR assumptions for the BISG systems can also be seen. First, the NHTSA effectiveness is 37% and 54% higher than assumed by EPA for the car and truck examples respectively, and both are higher than in 2012. Second, the cost assumed by NHTSA is higher than that of EPA, which does correlate with the higher effectiveness. However, the difference in assumed electric machine power rating does not correlate with either the cost or effectiveness differences. The Agencies need to re-evaluate the correct costs and effectiveness that should be applied for BISG and CISG, as opposed to simply merging the two tables. This should be done in a collaborative manner where automaker input is considered, not just that of suppliers who do not have to integrate parts into complete vehicles or be concerned with compliance requirements which may limit their understanding of the total cost and task of increasing levels of technology in vehicles today.

In addition, the CAR Powertrain Study shows that a survey of automobile manufacturers found that for a medium size car, the average MY2017 cost is $1,388 and effectiveness is 8.8% to go from the baseline configuration to a 48V system.[130] This industry average shows a lower

[129] *Id.* at 5-302; 5-302, Table 5.85; 5-306, Table 5.89; 5-355, Table 5.124; 5.426, Table 5.183; 5/453, Table 5.207; 5-521.

[130] "An Assessment of Powertrain Technology Costs Associated with Meeting CAFE and GHG Standards." Center for Automotive Research. 2016. 13.

effectiveness than assumed by the Agencies and a significantly higher cost than the highest of the Agencies' estimates.

Finally, NHTSA assumes a different BISG system cost for a car versus a truck, which is a trend with which the Alliance agreesand supports.

As noted earlier, EPA does not consider a CISG system as a technology option in their fleet compliance modeling analysis while NHTSA does. However, the EPA does provide in the Draft TAR assumptions for the effectiveness of a CISG system. Tables B-3 and B-4 below compare Agency assumptions where data is available data for a car and truck example.

Table B-3: CISG Medium/Standard Car Comparison[129]

	Effectiveness	Electric Machine kW	Direct Manufacturing Cost	
			MY2017	MY2025
NHTSA	19.0%	15 kW	$2,588	$1538
EPA	15.0%	20 kW	Not provided	

Table B-4: CISG Truck Comparison[129]

	Effectiveness	Electric Machine kW	Direct Manufacturing Cost	
			MY2017	MY2025
NHTSA	14.0%	Not provided	$3,198	$1,905
EPA	12.2%	20 kW	Not provided	

As with the BISG system, the NHTSA assumptions for effectiveness are greater than those of EPA; 27% and 15% for the car and truck examples, respectively. In addition, NHTSA assumes a higher learning factor for the CISG system than they do for the BISG system, which results in a significantly greater cost reduction over time for the CISG system. The learning factors used by NHTSA in particular are problematic and extremely low for CISG. For CISG, the Agency predicts a 20% greater reduction in costs in MY2025, compared to the case for strong hybrids. It is not clear why NHTSA assumed such a learning curve is the case and the Alliance believes this decision should be revisited.

As is the case for many fuel efficiency technologies, mild hybrids do not simply "bolt on" to provide reductions; they affect nearly every system on a vehicle which makes the true cost much greater than just the direct manufacturing cost price of the motor, belt, and larger battery. In addition to the costs of the mild hybrid technology itself, automakers must consider many competing technical constraints. It may be the case that the suppliers from which the Agencies obtained their cost data failed to consider these issues. The following list points to OEM technical concerns that must be addressed to maintain customer satisfaction:

- Mitigation may be needed to reduce engine shutdown torque pulses with BISG.
- Robust engine position parking is required.
- Robust engine starts must account for NVH concerns.
- Increased belt tension may be needed to provide repeatable torque (especially for part throttle assist and regeneration maneuvers).
- Increased belt pulley ribs may be necessary. (Eight to ten rib belts could cause increased accessory drive friction)
- BISG strategy may require adjustment for light tip-ins and to prevent transmission downshifting.
- BISG battery regeneration strategy could change with battery durability concerns.
- When activating cylinder deactivation, there is not an unlimited amount of energy available to improve "fly zone" NVH operation.
- These technologies could include additional mass that is not taken into account.
- There are still concerns over belt life and maintenance.

Market Penetration

As the Agencies have noted, market uptake of hybrid technology has not grown as was expected, but has dropped by 23% since its peak market penetration in MY2010. This may have been due to low fuel prices as well as other factors.[131] With the shift from 115V to 48V systems, the cost of these systems will decrease as the Agencies note, which could make the payback for customers more attractive. These modeled savings, however, might not translate to the customer due to overly optimistic cost projections. There are still further challenges for the automakers when trying to reach the large market penetrations for this technology predicted by the Agencies for the MY22-25 timeframe.

Although customers will see benefits from this system in real-world driving conditions, all of this benefit is not realized by the on-cycle test procedures. This significantly impacts the fuel-reduction-versus-cost-ratio that manufacturers must optimize when selecting technologies to implement to meet the regulatory standards. While the current stop-start table credit attempts to address this gap, there are three reasons that a mild hybrid will result in a higher off-cycle benefit than captured with the current stop-start table value:

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[131] 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, (EPA-420-D-16-900, July 2016) at 3-13.

1. Idle fraction off-cycle is much higher in the real world than on-cycle, as shown in the Daimler start-stop petition.[132] Similarly, the fraction of stops per vehicle mile travelled (VMT) is higher in the real world than on the combined cycle.
2. Since the fraction of stops per VMT are higher in the real world than on the combined cycle, the greater "stop related" Mild hybrids benefits should be recognized. Mild Hybrids can have a greater "window" of engine off operation including launch (or torque) assist due, in part, to opportunity regeneration, than stop-start systems alone.
3. Mild hybrid systems enable engine-off coasting (sailing) during real-world city and highway driving conditions that are not captured on-cycle.

The Agencies should consider a revised adjustment factor, or off-cycle credit value, to account for these benefits. Due to the significant off-cycle potential that mild hybrids provide, simply adding a credit for mild hybrids to the existing off-cycle program with table caps is not reasonable. There are three options to consider. Option one would be to eliminate the table caps to ensure the off-cycle benefits of all future technologies are fully recognized for the real-world fuel consumption reduction they provide. Option two would be to increase the table credit cap. Finally, option three would be to exclude mild hybrid technologies from the cap calculation. It is important that all technologies that provide additional off-cycle fuel savings be recognized to promote implementation of these technologies by manufacturers. In addition, it is equally important that manufacturers have a defined value for these credits to allow for product planning. If a table value or adjustment factor is not defined during the planning phase, technologies may be excluded due to uncertainty and risk. This could lead to higher cost solutions that the market may not be able to support.

Power Split vs. P2 Hybrids

The Draft TAR analysis considers both power-split and P2 hybrids simply as "strong hybrids" with identical cost and effectiveness assumptions. This simplification discounts the fundamental architectural differences between these two technologies, which have different packaging requirements, efficiency potentials, and vehicle applications. The Alliance recommends that EPA develop separate cost and effectiveness projections for power-split and P2 hybrids.

Separate Battery Costs and Technology Discussion

The Alliance has concerns with some of the battery-related assumptions the Agencies have made in the Draft TAR. However, it is not possible to complete a thorough evaluation of the discussions surrounding batteries in the 60-day timeframe. Some initial feedback for the

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[132] Light Duty Greenhouse Gas Standards Compliance Information. Requests for Off-Cycle Credits - Merecedes-Benz. U.S. Environmental Protection Agency. Accessed September 26, 2016. https://www3.epa.gov/otaq/regs/ld-hwy/greenhouse/ld-ghg.htm.

Agencies is to ensure costs assumptions are not just for energy cells, and to present what size the system is relative to cost, as there are economies of scale and large battery system costs can be different from those for mild or even strong hybrids used by the automotive industry. Further, it may be more appropriate for the Agencies to use different cost metrics for mild hybrids reflecting different usage and requirements for these systems.

In addition, while there may be some learning for battery manufacturers, there are also many tradeoffs with this technology that will require extensive research and development (R&D) which must be considered especially for any new and yet to be discovered chemistries, cooling methods, or additional safety concepts.

Finally, in determining the average range characteristic of BEVs for MY2014 used in the development of the baseline and/or reference fleet, the Agencies simply did a sales-weighted average to arrive at a value of 155.5 miles.[133] However, the data used suggests this may not be the most appropriate way to calculate this value because some 77% of the listed models have ranges of less than 87 miles. It is only when considering Tesla vehicles with ranges of 200 or 270 miles that the average increases to 155.5 miles. Further work should be done to consider the most appropriate way to determine the average range characteristics of the fleet for use in development of the reference and/or baseline fleet.

Octane - The Missed Powertrain Technology Option

The Agencies tested some engine technologies (e.g. downsized turbocharged engines) on high octane Tier 2 certification fuel. The Alliance has commented that re-assessment of certain engine technologies on Tier 3 certification fuel is necessary to arrive at an accurate assessment of fuel economy and GHG benefits given that the use of Tier 3 certification fuel is mandated during the timeframe discussed in the Draft TAR. That said, it is unfortunate that the Agencies did not include octane as a technology analogous to powertrain technology options they did study.

Government agencies worldwide, including the United States, are requiring aggressive improvements in vehicle fuel economy and greenhouse gas emissions. Achieving these improvements will be challenging, and will require significant changes in all aspects of vehicle design, including changes to engines and transmissions. In meeting this challenge, engine efficiency improvements are being implemented on all new light-duty vehicles. These efficiency improvements include higher compression ratio engines, engine displacement downsizing, turbocharging, down-speeding, and hybridization.

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[133] 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, (EPA-420-D-16-900, July 2016) at 4-47,Table 4.35.

The co-design of fuels and engines is an important pathway to improve fuel economy in spark ignition gasoline engines. The widespread availability of higher octane rated gasoline (having increased knock resistance) is a key enabler for the next phase of advanced engines expected to occupy a large fraction of the vehicle fleet. In addition, the implementation of higher octane rated gasoline in the marketplace could be a cost-effective means of immediately improving fuel economy across a substantial portion of the existing light-duty vehicle fleet.

Auto manufacturers support bringing high octane fuels to market that are aligned with future engine technologies and vehicles that are designed and optimized to take full advantage of the performance qualities of those fuels.

Automakers oppose the sale in any U.S. jurisdiction of so-called sub-grade gasoline (<87AKI [Anti-Knock Index]) regardless of altitude, climate or artifacts of use allowed in ASTM 4814. Such fuel degrades performance for the current fleet and constrains manufacturers' ability to design prospective engine technology that can improve engine and fuel efficiency toward better fuel economy and reduced GHG.

Strategies need to be implemented to avoid using sub-standard octane in an engine optimally designed for a high octane fuel that will result in decreased fuel economy and performance, and could possibly result in engine damage. Thus, it is imperative that customers use the proper fuel for which their vehicles are designed.

The widespread introduction of newly designed engines into the market is dependent not only on the universal availability of the requisite high octane fuel, but also the assurance that high octane fuel will be the fuel of choice for the customer. Action is needed to ensure higher octane fuel will enable smaller higher compression engines that could require additional anti-knock protection to accommodate new engine technologies.

Mass Reduction

The methods and data chosen by the Agencies to predict mass reduction strategies and cost curves have led to overly optimistic projections. The Alliance believes that mass reduction is a viable pathway for improving fuel economy and CO_2 emissions, albeit at a higher cost and with likely longer lead-times than projected by either Agency. Using a materials-based approach, identifying real world constraints, correctly evaluating current vehicle baselines, and further considering the "mass-add-back" likely needed for future regulatory and customer requirements would help to correct the over-optimistic projections. The Alliance seeks to work with the Agencies at identifying mass reduction pathways and establishing more representative costs of mass reduction.

Real World Complexity

The Agencies, in their analysis of mass reduction pathways and the associated costs, do not fully account for significant real-world complexity. This is not to say that mass reduction is not possible, merely more expensive and perhaps requiring more time than clean-sheet studies would indicate absent real-world constraints. These real world constraints, as explained in a recent CAR research paper[134] (attached as Attachment 9) include: "how new materials and processes are developed; physical facility infrastructure constraints; requirements for globally competitive supply chains; proliferation of global platforms; customer acceptance and the need to constantly improve ride and handling; and product development processes (and resources) that are not designed to optimize vehicles specifically for fuel economy."[135] The paper continues to note "[i]t is broadly acknowledged that the realized cost may be significantly higher than the idealized analyses."[136] We caution the Agencies to apply good engineering judgement if they continue to rely on "clean sheet" analyses as the basis for determining mass reduction strategies and costs.

Tear Down Studies of Non-Optimized Vehicle Designs

The Alliance agrees with a recent 2015 National Academies of Science report where it recommends that mass reduction the teardown be augmented with materials-based studies: "The committee recommends that the Agencies augment their current work with a materials-based approach that looks across the fleet to better define opportunities and costs for implementing lightweighting techniques…"[137]

The Agencies largely used three teardown studies to develop mass reduction pathways and cost curves. The results of these three teardown studies have been published (Venza,[138] Accord[139] and the 2011 MY Silverado[140]) and a fourth study is still in peer review (2014 MY Silverado).[141] Today's fleet is well past the technology used in the first three vehicles.

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[134] "Identifying Real World Barriers to Implementing Lightweighting Technologies and Challenges in Estimating the Increase in Costs." Center for Automotive Research. 2016.
[135] *Id.* at 18.
[136] *Id.* at 18.
[137] "Cost, Effectiveness and Deployment of Fuel Economy Technologies for Light-Duty Vehicles." National Academy of Sciences, National Research Council to the National Academies. 2015. 12.
[138] "Light-Duty Vehicle Mass Reduction and Cost Analysis – Midsize Crossover Utility Vehicle." U.S. Environmental Protection Agency. EPA-420-R-12-026. 2012. Accessed September 26, 2016. https://www3.epa.gov/otaq/climate/documents/420r12026.pdf.
[139] "Mass Reduction for Light-Duty Vehicles for Model Years 2017-2025." National Highway Traffic Safety Administration. 2012. Accessed September 26, 2016. ftp://ftp.nhtsa.dot.gov/CAFE/2017-25_Final/811666.pdf.
[140] "Mass Reduction and Cost Analysis – Light-Duty Pickup Truck Model Years 2020-2025." U.S. Environmental Protection Agency. EPA-420-R-15-006. 2015. Accessed September 26, 2016. https://www3.epa.gov/otaq/climate/documents/mte/420r15006.pdf.

The 2011MY Silverado was built off of the GMT900 platform that was launched in 2006. The GMT900 was itself designed from the GMT800 platform that was launched in 1998. Even though material was substituted in the 2006 redesign, the architecture was not optimized for mass reduction. By using the MY2011 Silverado, the EPA essentially over-projects the mass reduction opportunities compared to the more recently optimized platforms.

Similarly, the Toyota Venza is not a current state-of-art Toyota design. The Venza was not a mass optimized design and included significant content from the Toyota Highlander and Camry. Also, the Venza analyzed by EPA was designed for two engines. The EPA analysis examined the Venza model with the smaller of the two engines. The Venza mass reduction study would therefore be optimized for one engine and not take into account the broader utility of the Venza with the larger engine. The Venza study contains the two fundamental issues of starting with a non-optimized vehicle and ignoring the full range utility of the Venza. This leads to an overly optimistic evaluation of low cost mass reduction pathways compared to optimized vehicle designs that must account for all the applications of a given platform.

The Honda Accord study performed by EDAG GmbH for NTHSA[142] and the MY2014 Silverado study[143] may more accurately portray mass reduction pathways and possible associated costs. While industry generally agrees with the potential pathways explored in the Honda Accord study, we believe the EDAG cost curve, Figure B-7, should be updated to reflect Honda feedback and recent CAR findings.[144] CAR findings include the need for several adjustments to the EDAG cost curve including: adjusting the baseline to reflect the current state of technology, accounting for barriers to implementation, recognizing less mass de-compounding may be actually realized, and providing for "mass add-back."

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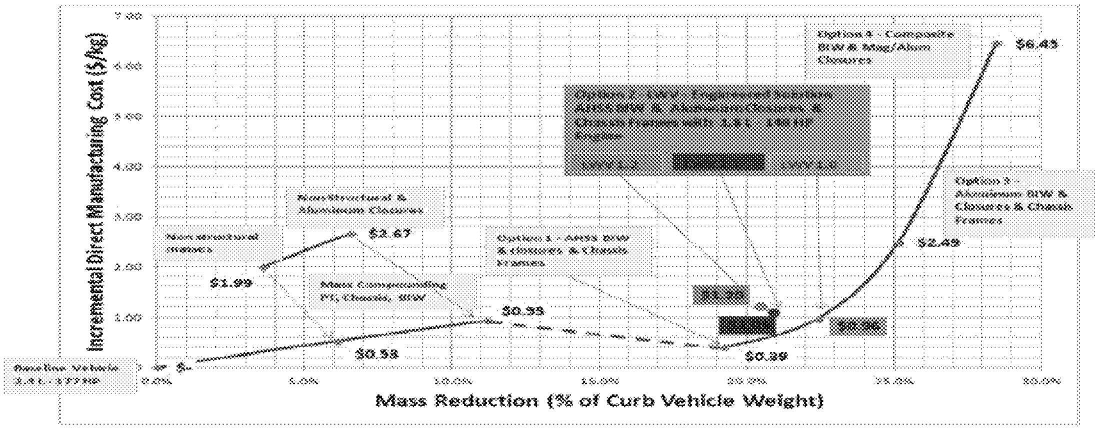
[141] Draft Technical Assessment Report: Midterm Evaluation of Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards for Model Years 2022-2025, (EPA-420-D-16-900, July 2016) at 5-168.
[142] "Mass Reduction for Light-Duty Vehicles for Model Years 2017-2025." National Highway Traffic Safety Administration. 2012. Accessed September 26, 2016. ftp://ftp.nhtsa.dot.gov/CAFE/2017-25_Final/811666.pdf.
[143] 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, (EPA-420-D-16-900, July 2016) at 5-168.
[144] "Assessing the Fleet-Wide Material Technology and Costs to Lightweight Vehicles." Center for Automotive Research. 2016.



Source: EDAG Honda Accord MY2011 study, Singh, Harry. (2012, August)

Figure B-7: EDAG Cost Curve

While the Alliance does not yet have final cost curves based on the all the recommended adjustments, we expect the new baseline and "mass add-back" will effectively push the curve to the left on the x axis above. Furthermore, real-world barriers and less realized mass de-compounding will result in steeper cost curve and/or push the cost curve further to the left.

In summary, concerns with the Agency mass reduction analyses include: insufficient attention paid to real world manufacturer constraints, the need to include "mass add-back", baseline issues, and tear down analysis including dated or non-optimized vehicle designs all used to establish optimistic cost curves. The Alliance and its members look forward to working with the Agencies in developing cost curves that are more reflective of the current and near-term state of the industry.

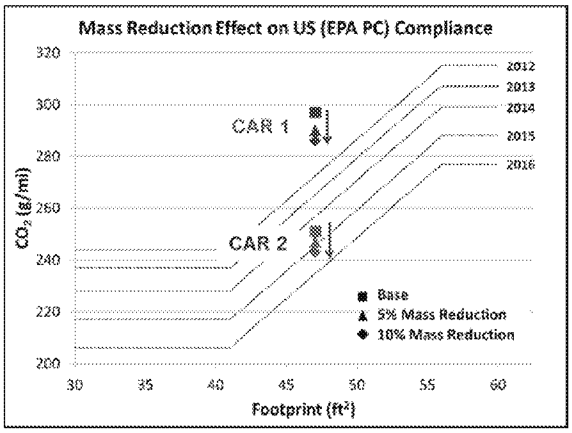
Mass Reduction Has Different Impacts in Other Regulatory Structures

The Agencies have noted mass reduction is a viable option for improving fuel economy. Manufactures agree, but face constraints. It is important to note that, of the major markets, only the U.S. has a footprint-based GHG and FE regulatory structure. Many countries have mass-based regulatory structures as show in Table B-5.

Table B-5: Compliance Attributes

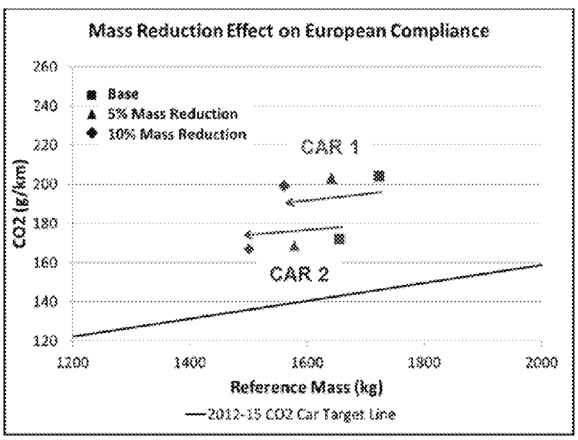
	United States	Europe	China	Brazil
Compliance Method	Fleet Average	Fleet Average EU28+Norway+Iceland (Switzerland specific fleet)	Fleet Average & Per Vehicle Limits	Fleet Average
Attribute	Footprint	Mass	Mass	Mass

The regulatory structure matters because mass reductions to vehicles in other markets contribute significantly less to an automaker's regulatory compliance as illustrated below. It would be helpful to understand the Agencies' perspective on this issue and the need for volume application of technologies to minimize costs as depicted in Figures B-7 and B-8. Minimizing costs improves customer acceptance and thereby realizes environmental improvement.



Mass reduction impacts compliance in the U.S. footprint based system.

Figure B-8: Mass Reduction Effect on US Compliance



Mass reduction has significantly less impact in the EU's mass based system.

Figure B-8: Mass Reduction Effect on European Compliance

Aerodynamic Load Reduction

EPA and NHTSA have pursued different paths for defining the initial aerodynamic state of the vehicles in their baseline fleets. EPA used methodology from Novation Analytics where frontal area is calculated from vehicle and tire dimensions, and the drag coefficient (C_d) is mathematically derived from coastdown data.[145] NHTSA simply relied on manufacturer-reported data.

As an example of the difference in results, EPA defines a 3.6L Chrysler 300 as having a C_d of 0.332 with a frontal area of 26.02 ft^2. NHTSA reports the same vehicle as having a C_d of 0.318 with a frontal area of 25.8 ft^2. This represents a 5% difference in the product of Cd and frontal area (C_dA).

Regardless of what was calculated, EPA gave no credit for vehicles that were already aerodynamically improved. This means that all vehicles in their analysis are considered candidates for up to 20% more aerodynamic improvement.

NHTSA pursued a more sophisticated approach. This included defining an average C_d for nine vehicle types (sedan, coupe, minivan, hatchback, convertible, wagon, SUV, van, and pickup) and specifying a vehicle as "AERO10" or "AERO20" if that vehicle's C_d was 10% or 20% below average for its type.[146]

Of the two methods, we support NHTSA's methodology with the following suggestions:

1. As the Draft TAR is intended as a review of the MY2017-2025 rulemaking, which in turn was based on MY2008 and MY2010 fleets, the average Cd values for the various vehicle types should also be derived from MY2008 or MY2010 vehicles. By comparing to older vehicles, the progress that manufacturers have made with respect to the vehicles used in the rulemaking will be properly reflected. If the Agencies continually compare a vehicle's present status against the fleet's present status, manufacturers will never achieve the 10% or 20% aerodynamic improvements called for by the Agencies' models.

2. Using older vehicles as recommended above may necessitate using Novation Analytics' methodology for defining C_d and frontal area since the data used to calculate the parameters is still readily available. While this method is empirical, it has the advantage

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[145] *See* "Technical Analysis of Vehicle Load Reduction Potential For Advanced Clean Cars" ControlTec, LLC. 2015. Docket ID EPA-HQ-OAR-2015-0827-0153.
[146] 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, (EPA-420-D-16-900, July 2016) at 4-62, Table 4.55.

of being consistent for all vehicles and avoids the variations in facilities and methodology with which manufacturers measure C_d.

3. NHTSA's method of calculating an average C_d and then multiplying by 0.9 or 0.8 to achieve a target C_d for AERO10 and AERO20, respectively, is mathematically convenient but disconnected from the data they report. For example, the pickup class of vehicles shows an average C_d of 0.395, which is 10% and 20% less than that average yields targets of 0.355 and 0.316 for AERO10 and AERO20. Both of these targets are lower than the best C_d reported by any manufacturer, suggesting that the targets may be infeasible. Instead of considering every vehicle as a candidate for a 20% aerodynamic improvement, a more realistic limit may be the best-in-class 90th percentile value. This was the level used by Novation Analytics for their work for CARB.[147] Along with this suggestion, the Agencies should also consider reducing the step size from 10% to 5%. This will provide greater resolution in the results and also avoid the possibility of having to stop at 10% if 15% is the maximum feasible limit.

4. NHTSA's method for analyzing baseline aerodynamics requires that a manufacturer achieve 10% better than average C_d for a vehicle to be considered AERO10. That vehicle would remain AERO10 until 20% better than average was attained. A more just approach would be to have 10% as the center of the range instead of the start of the range. For example, an AERO10 vehicle should be any vehicle that is 5% to 15% better than average. This is consistent with NHTSA's method for mass reduction where a vehicle is considered to have 5% mass reduction (MR1) for the range of 3.75% to 5.625% below trend.

Plausibility for EPA Application of Aerodynamic Improvements

Within the OMEGA technology package outputs for the MY2025 control case central analysis, EPA applies AERO2 (20% aerodynamic load reduction) to approximately 93% of the modeled MY2025 fleet.[148] Given the issues identified in establishing the baseline aerodynamic improvements[149] and sound engineering practice, it makes sense to provide a check for the plausibility of achieving 20% aerodynamic improvements across such a wide range of vehicles.

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[147] "Technical Analysis of Vehicle Load Reduction Potential For Advanced Clean Cars" ControlTec, LLC. 2015. 34.
[148] Optimization Model for reducing Emissions of Greenhouse gases from Automobiles (OMEGA). OMEGA pre-processor, Technology cost development, and Input/Output files used in the Draft TAR analysis. OMEGA output files for the MY2025 Control Case Central Analysis. U.S. Environmental Protection Agency. Accessed September 26, 2016. https://www3.epa.gov/otaq/climate/documents/omega-tar2016.zip.
[149] See Appendix C in these comments, describing Alliance concerns that EPA has assumed that no vehicles in the 2014MY baseline had any aerodynamic improvements.

As described by the Agencies in the Draft TAR (Section 5.2.5.1), there are generally two components of aerodynamic load for a vehicle--the frontal area and coefficient of drag. Reducing either component will minimize the effective aerodynamic load experienced by a vehicle. Vehicle frontal area can be modified by changing a vehicle's overall height and/or width, but reducing either by a significant amount would likely impact interior passenger space. Assuming that EPA is not suggesting significant body dimensional changes (which would not be in the spirit of maintaining current vehicle performance), the modeled improvements in aerodynamic resistance must therefore be based primarily on improvements in the coefficient of drag.[150]

As a rough check of the plausibility of achieving 20% aerodynamic improvements across nearly the entire MY2025 control fleet, the Alliance makes a simple comparison of the resulting coefficients of drag in the MY2025 control fleet to a present vehicle with generally accepted superior aerodynamic performance. The following steps were performed:

1. Determined MY2025 control fleet vehicles to which the Aero2 technology is applied by examining OMEGA model outputs.
2. Applied a 20% reduction to the coefficient of drag reported in the EPA "2014MY Baseline with Tech and Market Tabs for Docket" file[151] for each of the vehicles with Aero2 technology applied in the MY2025 control fleet.
3. Compared the resulting improved drag coefficients to a MY2014 baseline vehicle as a proxy test for plausibility.
4. Identified examples which did not appear reasonable.

The Tesla Model S was the MY2014 vehicle chosen for comparison to the modeled MY2025 vehicles with 20% aerodynamic drag reduction. The Tesla Model S is broadly accepted as one of the most aerodynamic vehicles available in the 2014 model year.[152,153] Furthermore, because of its design as a battery electric vehicle sports sedan, the Tesla Model S includes a number of passive aerodynamic features including an aerodynamic body design, full underbody panel (the battery), relatively low ground clearance, and door handles which are completely flush to the body when not in use. The Tesla Model S design also passively implements features for which a

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[150] This assumption is further supported by Draft TAR p. 5-145 et seq. Section 5.2.5.3.1 which primarily focuses on recent vehicle changes which impacted the coefficient of drag with limited discussion of frontal area modifications.
[151] Docket ID EPA-HQ-OAR-2015-0827-0402.
[152] *See* 10 of the Sleekest Cars on the Road. The Cheat Sheet. Accessed September 7, 2016. http://www.cheatsheet.com/automobiles/wave-of-the-future-10-of-the-sleekest-cars-on-the-road.html/?a=viewall.
[153] *See* 12 of the Most Aerodynamic Cars in Production Right Now. Motorburn. Accessed September 7, 2016. http://motorburn.com/2014/01/12-of-the-most-aerodynamic-cars-in-production-right-now/.

conventional vehicle would generally require active implementation—such as grill shutters.[154] Many of these features can be seen in Figure B-9.

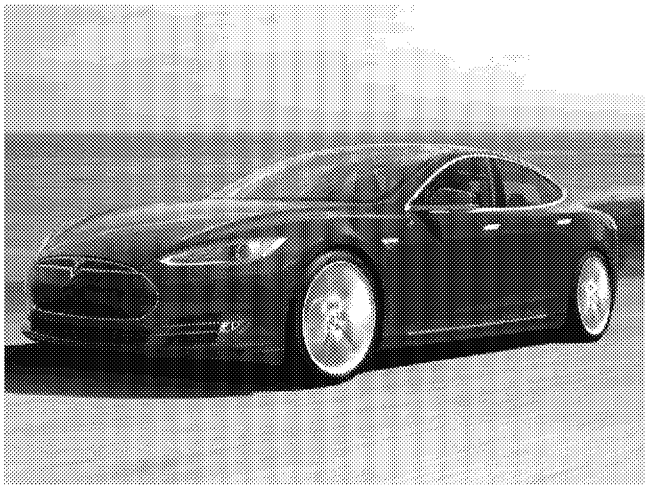

Figure B-9: 2014 MY Tesla Model S

When 20% aerodynamic drag reductions are applied to the MY2025 control fleet as modeled by EPA and then compared to the MY2014 Tesla Model S, approximately 54% of all modeled MY2025 vehicles have a coefficient of drag equal to or better than the MY2014 Tesla Model S. A closer review of these results reveals several vehicles which would not seem to be plausibly able to improve coefficients of drag to the degree required without significant changes to the vehicle design and resulting functionality. For example, multiple large future SUVs such as the Nissan Armada[155] (Figure B-10) have coefficients of drag equivalent to the present Tesla Model S. Additional examples exist of large SUVs becoming better than the Tesla Model S such as the GMC Yukon Denali[156] (Figure B-11). A visual comparison of these vehicle types to the Tesla Model S suggests that regardless of the number of passive and aerodynamic features added, the likelihood of achieving Tesla Model S drag coefficients appears low.

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[154] Active grill shutters seal the front grill radiator opening on conventional internal combustion engine (ICE) vehicles. In contrast, the Model S front end is generally closed off already in its design because a large radiator for an ICE is not needed.

[155] Optimization Model for reducing Emissions of Greenhouse gases from Automobiles (OMEGA). OMEGA pre-processor, Technology cost development, and Input/Output files used in the Draft TAR analysis. OMEGA output files for the MY2025 Control Case Central Analysis. U.S. Environmental Protection Agency. Accessed September 26, 2016. https://www3.epa.gov/otaq/climate/documents/omega-tar2016.zip. OMEGA vehicle index numbers 1721-1728

[156] *Id.*, OMEGA vehicle index number 1076.

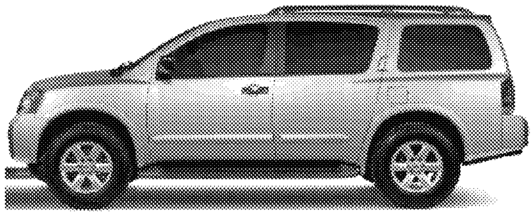

Figure B-10: 2014 MY Nissan Armada

Figure B-11: 2014 MY GMC Yukon Denali

This simple comparison of estimated future drag coefficients to an exemplar MY2014 vehicle demonstrates why a robust plausibility check of modeled future aerodynamic improvements must be performed. The Alliance recommends that the Agencies develop such a plausibility check before the next step of the MTE and apply the check to all vehicles with modeled aerodynamic improvements.[157] Such a check should consider, but is not limited to, type of vehicle and aerodynamic improvements already implemented for the specific vehicle. The Agencies should also consider the vehicle functional requirements (e.g. off-road capability) in determining the types of aerodynamic improvements that could reasonably be applied.

Tire Rolling Resistance

While the Draft TAR is optimistic that concerns about wet traction and durability of low rolling resistance tires can be resolved, the 2015 NAS Report[158] was more realistic in noting that these problems continue to present engineering challenges. This is also reflected in the preliminary

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[157] *See* Appendix A of thse comments for further discussion on other recommended plaubility checks.
[158] "Cost, Effectiveness and Deployment of Fuel Economy Technologies for Light-Duty Vehicles." National Academy of Sciences, National Research Council to the National Academies. 2015. 242.

and limited data from the Transport Canada/Natural Resources Canada study shown in Draft TAR Figure 5.47.[159] While one tire with low rolling resistance and good wet traction was noted, the overall trend shows that wet traction cannot be ignored, and that there may be limits on how much overall reduction the industry can achieve.

Impact Analysis

The Alliance performed an analysis to demonstrate the impact the identified issues in EPA's vehicle-level simulations can have on fleet level compliance. The analysis revealed that the net cumulative effect is, at minimum, 20 g CO_2/mile for the average car and 30 g CO_2/mile for the average truck from over-estimating the effectiveness of multiple technologies such as the Advanced Atkinson Technology Package, downsized boosted engines, HEG transmissions, overlooking the impact of regulatory mandates like EPA's tier 3 compliance and 1 mg/mi PM compliance. These differences equate to multiple years of stringency. There are additional issues, not covered in the analysis which would lead to an even greater effectiveness gap, including modeling application errors, CREE deterioration factors, and other issues.

Given the magnitude of the projected shortfall for conventional vehicles, the only remaining technologies available to automakers that meet or exceed the MY2025 standards are electrified products. The Alliance disagrees with the Agencies' conclusion that the MY2022-2025 standards can be met largely with more efficient non-hybrid conventional powered cars at the costs stated in the Draft TAR.

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[159] 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, (EPA-420-D-16-900, July 2016) at 5-156.

Appendix C: Baseline Fleet Development

A critical step in modeling the technologies (and associated costs) required to bring the future light-duty fleet into compliance with the MY2022-2025 standards is an accurate understanding of the technologies already in use on today's vehicles. Knowledge of the technologies already in use prevents "double counting" of technologies' costs and benefits as noted by EPA.[160] Errors in this step of the process can ultimately result in underestimating the penetration of more advanced technologies required for compliance and the costs for doing so. They can also lead to implausible applications of additional levels of technology.

The Alliance has identified several issues in the Agencies' development of their respective baseline fleets which we believe will ultimately result in significant errors in the assessment of the technologies required for compliance in the future, if left uncorrected. These issues are described in detail below.

Additional issues with the baseline fleets developed for the Draft TAR may be identified at a later time. We note that in creating two separate baseline fleets (MY2014 for EPA and MY2015 for NHTSA), the Agencies have doubled the workload required for stakeholders to review the data and processes associated with the baseline fleet assessment. Therefore, only a preliminary review of this critical step could be completed in the timeframe alloted for these comments.

Selection of Baseline Model Year

In the Draft TAR, the Agencies chose different model years for their analysis–MY2014 (EPA) and MY2015 (NHTSA). The Alliance supports the use of the most recent data available in establishing the baseline fleet, and therefore believes that NHTSA's selection was more appropriate for the Draft TAR.

We support both Agencies' intent to use the most recent data available for the analysis which will inform the next step of the MTE. We urge EPA to consider aligning with NHTSA to the more recent model year for which GHG and FE data on a vehicle-level basis is available. We note that final model year data must be submitted within 90 days after the end of the model year.[161] We recommend that the next step of the MTE process (assuming CY2017) be timed to allow both Agencies to utilize MY2016 final data. Such alignment would result in greater consistency between the Agencies' respective assessments, would capture the latest technology

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[160] 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, (EPA-420-D-16-900, July 2016) at 4-1.
[161] 40 CFR § 600.512-12.

information available in the present fleet, and would ease the burden on stakeholders reviewing future baseline assessments.

Determination of Baseline Mass Reduction

In the Draft TAR, at Sections 4.2.10.1 (NHTSA)[162] and 5.3.4.6.2 (EPA)[163], the Agencies describe their efforts to estimate the level of mass reduction in existence in their respective baseline fleets. The Alliance agrees that determining the existing level of vehicle mass reduction technologies already applied is a critical step to ensure that the projected future level of mass reduction applied is feasible and practicable, and that the costs of such future mass reduction are appropriately taken into account. However, neither of the Agencies' approaches fully consider, nor properly account for, mass reduction technologies applied in their respective baseline fleets.

Mass Reduction Measures Already Implemented

A key issue in determining the feasible and practicable level of mass reduction potential for any given vehicle, and the costs associated with that mass reduction, is the degree of design optimization and lightweight material application already applied to that vehicle.

Manufacturers have already added significant mass reduction technologies. A recent study by the Center for Automotive Research[164] investigated mass reduction strategies and the degree of mass reduction technology already applied by nine manufacturers for vehicles representing nearly 50% of the new vehicle market. Every vehicle surveyed contained a higher level of mass reduction technology (e.g. use of high-strength steels and/or aluminum) than the 2011 Honda Accord and 2011 Chevrolet Silverado used to establish the mass reduction cost curves in the 2012 FRM.[165,166] In fact, the study found that some of the vehicles have already applied advanced high-strength steels (AHSS) to the point described as Option 1 (AHSS body-in-white (BIW) & closures & chassis frames) noted in the 2011 Honda Accord study.[167] At the time the CAR study was begun, the NHTSA 2014 Silverado study was not publicly available, so no comparison was made. The Alliance may consider requesting that CAR provide additional analysis relative to the 2014 Silverado study to inform supplementary comments after the close of the Draft TAR comment period.

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[162] 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, (EPA-420-D-16-900, July 2016) at 4-65 et seq.
[163] *Id.* at 5-394 et seq.
[164] "Assessing the Fleet-Wide Technology and Costs to Lightweight Vehicles." Center for Automotive Research. 2016.
[165] *Id.* at 22.
[166] *Id.* at 24.
[167] *Id.* at 35.

Consideration of Mass Reduction Design and Technologies Applied Without Concurrent Curb Weight Reductions

Although manufacturers have already engaged in significant application of advanced high-strength steels, aluminum, and other lightweight materials, not all of the improvements have resulted in net mass reduction. The reason for this is that there are many other additional features desired (and in many cases expected) by automotive customers which add mass, thereby reducing the observed benefits of mass reduction technologies. Nonetheless, manufacturers still have already applied additional mass reduction technologies upon which the mass reduction cost curves are premised.

The Alliance agrees with the premise that mass reduction technologies do not provide the expected GHG and FE benefits when other mass additions offset their benefits. However, it is wholly inaccurate not to account for added mass reduction technologies in terms of the overall cost to add the next stage of mass reduction technology. The concept underlying the mass reduction cost curves is that added technologies will increase cost, typically commensurate with the types of material and designs selected. Not accounting for the actual level of mass reduction technology already implemented on specific vehicles leads to underestimation of future vehicle costs.

The Agencies have approached this issue in two ways. EPA has provided direct offsets for a limited number of changes which increase mass relative to the baseline vehicles (mass associated with safety technology and increases in vehicle footprint). NHTSA has approached this issue on a statistical basis similar to that taken in a recent vehicle load reduction study by ControlTec, LLC (ControlTec Load Reduction Study).[168] Both of these approaches have positive and negative aspects. The EPA approach provides direct accounting for some mass increases, but fails to consider other potential mass increases which could result in underestimation of the level of technology already applied. The NHTSA approach assumes that any vehicle with less than the best demonstrated curb weight has potential for improvement, but the approach still does not adequately capture the degree to which mass reduction technologies have already been applied.

The Alliance's concerns can be demonstrated with a simple example. The Ford F150 pickup truck was redesigned for MY2015 and incorporates an aluminum-intensive BIW, advanced highstrength steel frame, and secondary mass reductions including engine downsizing. This level of mass reduction technology is generally described on the Agencies' light-duty truck direct manufacturing cost curve as the AHSS + AL Solution (LWV), which is shown at

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[168] "Technical Analysis of Vehicle Load Reduction Potential for Advanced Clean Cars." ControlTec, LLC. 2015. Docket ID EPA-HQ-OAR-2015-0827-0153.

approximately 17-18% mass reduction.[169] However, the EPA process suggests only a 14% reduction relative to the cost curve was achieved by the redesigned Ford F150.[170] The NHTSA process similarly understates the degree of mass reduction technology applied with an estimate of only 10% mass reduction technology applied (level "MR3").[171] Although this is just a single example, we believe it is probable that many more vehicles are subject to the same issues based on the Agencies' processes for determining the level of mass reduction present in the baseline fleet. The process (or processes) to estimate baseline mass reduction must be improved prior to the proposed determination and proposed rulemaking.

Comments on the EPA Approach to Baseline Mass Reduction

The EPA approach to determining baseline mass reduction for the purposes of adjusting vehicle placement on the Agency-developed cost curves can be broadly described as being based on a percentage mass reduction observed for a particular vehicle in the MY2014 baseline fleet versus. its 2008 counterpart. There are several flaws to this approach. This approach assumes that no mass reduction activity occurred for any vehicle prior to the 2008 baseline relative to the study vehicles upon which the mass reduction cost curves are based. Another flaw is that manufacturers may have applied mass reduction technologies (therefore moving to the right on the estimated cost curve), but reductions were used to add other customer-desired features.

Lack of Analysis of Mass Reduction Technologies Applied in the 2008 Model Year Fleet

EPA describes that in the 2012 FRM, it was assumed that the MY2008 baseline fleet had zero mass reduction, and that for the Draft TAR, mass reduction is defined as a decrease in curb weight, relative to MY2008.[172] Although this is a convenient assumption to make, this approach fails to consider that it is quite likely that there was a distribution of vehicle mass reduction technologies around those considered as the zero mass reduction technology point on the estimated cost curves. (If, in fact, the mass reduction cost curves are relative to a null vehicle, then all vehicles in the MY2008 fleet would have mass reduction applied relative to the 0% point of the cost curves.) By treating all MY2008 vehicles as an average vehicle (or ignoring that all vehicles are likely to have improved past the null state), EPA, at minimum, underestimates the mass reduction starting point for many, if not all vehicles. The consequence of this is that the cost of projected mass reductions will be increased relative to the current projection (each pound of mass reduction is expected to have a higher incremental cost than the previous). In addition,

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[169] 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, (EPA-420-D-16-900, July 2016) at 5-384 and 5-426.
[170] *Id.* at 5-165, 5-398. Mass reduction of 13% shown in Table 5.14 adjusted by an additional 33.6 kg per Table 5.153.
[171] *Id.* at 4-71, 5-428. Ford F150 assigned to level MR3 per Table 4.49. Level MR3 is equivalent to 10% mass reduction per Table 5.179..
[172] *Id.* at 5-394.

the projected additional mass reductions projected for some vehicles may move beyond limits established by EPA (e.g. the 3,197 lb. minimum weight for OMEGA vehicle types 1-7 and 13)[173] or into material solutions that are not yet practical for mass production. EPA should consider a process to identify mass reduction technologies already applied relative to the 0% point of the mass reduction curves for the MY2008 fleet prior to the next step of the MTE process.

Adjustment of 2008 / 2014 Curb Weights for 4WD / AWD vs. 2WD

In the Draft TAR, EPA describes the process used to adjust MY2008 and MY2014 curb weights for the presence of four-wheel drive or all-wheel drive (4WD / AWD) systems relative to two-wheel drive (2WD) variants.[174] Exactly how these adjustments were applied and their impact on the analysis is unclear due to the lack of a document showing the specific calculations as actually applied to the fleets. In general, the description of why this adjustment is made was confusing and failed to provide insight to readers that are not privy to the calculations made. The Alliance reserves judgment on the specific application of the analysis pending further review.

Although it is unclear exactly how these adjustments were applied to the baseline vehicles, the data used to derive the adjustment factor itself was clear. EPA describes an evaluation of three different vehicles with both 2WD and 4WD / AWD systems and the curb weight difference for each. The average of these three vehicles is taken and then rounded down to the nearest 100 lb. The Alliance notes that three vehicles are hardly a representative sample when EPA itself has extensive databases of certification data (e.g. Verify) that include data on drive configuration and curb weight. Use of such databases (after filtering to ensure similar levels of other features) could prove to be a more robust source of data. Presuming that the three vehicles measured in the referenced study do actually represent typical 4WD/AWD systems, it would have been more appropriate to weight the average by the number of sales of the different system types. For example, if the majority of 4WD/AWD systems are more similar to the Ford Fusion (an AWD system designed for improved traction in a passenger car), the average would move towards lighter weights Conversely, if the majority are more similar to the Jeep Cherokee (a full 4WD system designed for extreme off-road use), the average would move towards heavier weights. Although the time provided for comment on the Draft TAR is insufficient for the Alliance to provide a full numerical analysis to the EPA, we urge the Agency to develop a more robust analysis prior to the next step of the MTE.

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[173] *Id.* at 5-401.
[174] *Id.* at 5-395.

Adjustment of 2014MY Fleet Curb Weights for Footprint and Safety

The Alliance agrees that it is appropriate for the EPA to adjust the curb weight improvements for footprint increases and added safety features between MY2008 and MY2014.[175] This approach recognizes that mass reduction technology has been applied, but that other added features have resulted in a net mass savings lower than the theoretical mass reduction relative to the cost curves. We also concur with the Agency's intent to consider future safety related mass additions when determining the cost of net mass reductions and the capability for individual vehicles to reduce mass by a given percentage.[176]

The EPA provides estimates for mass added associated with safety improvements in the MY2008-2014 time period and for future safety improvements.[177] The Alliance reserves judgment on the appropriateness of the values presented and may choose to comment further in the future.

Lack of Consideration of Mass Reduction Technologies Applied Without Concurrent Curb Weight Reductions

EPA does not provide an adjustment to the resultant mass reduction cost curves in cases where mass reduction technology is applied, but the net mass reduction is less than the gross mass reduction expected from the technology application, except in the cases of added safety features and footprint increases.[178]

The Alliance recommends that the EPA undertake a more robust analysis of the types and levels of mass reduction technology applied in the baseline to replace the simplistic curb weight difference-based analysis prior to the next step of the MTE.

Comments on the NHTSA Approach to Baseline Mass Reduction

The NHTSA approach to establishing baseline mass reduction for the purposes of determining the costs of future mass reductions can broadly be summarized as a statistical evaluation of the MY2015 baseline fleet where vehicles are assigned an existing level of mass reduction based on analysis of the residuals from a regression analysis.[179] Vehicles with positive residuals (effectively higher mass than the predicted mass based on various vehicle features) were assigned a mass reduction of 0% (Level 0). Those with negative residuals (lower than predicted

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[175] *Id.* at 5-395 et seq.
[176] *Id.* at 5-402.
[177] *Id.* at 5-402.
[178] Although not directly stated in the Draft TAR, this is clearly evidenced by the simple calculation of the difference in MY2014 curb weight to the MY2008 curb weight.
[179] *Id.* at 4-65 et seq.

mass based on vehicle features) were assigned progressive levels of mass reduction already obtained, with the maximum level of mass reduction set at 15% (MR5).

Prediction of Curb Weight for Use in Determining Level of Mass Reduction Present

In NHTSA's approach, the regression model considered body design categories (3-Box, 2-Box, and Pickup), footprint, horsepower, electrification, battery pack size, drive configuration and whether the vehicle was a convertible. Adjusted R-squared values ranged from a low (poor correlation) of 0.461 for pickup trucks up to 0.883 for 2-box vehicle designs.[180] That higher correlation could not be achieved is a concern, especially for pickup trucks. It is indicative that the parameters chosen are likely insufficient to adequately predict curb weight. In the recent ControlTec Load Reduction Study, a similar analysis was performed and the key determinants of curb weight identified as vehicle cubic volume and vehicle type (accounting for 87% of variation in curb weight).[181]

Additional parameters were also identified which improved the correlation to 95%. The Alliance recommends that NHTSA review the ControlTec Load Reduction Study for consideration of additional parameters to improve the NHTSA model correlation to the baseline vehicle fleet.

The Alliance is also concerned with the approach taken of applying a regression model to determine the level of mass reduction technology applied. Although we agree that a regression model may be useful for comparing actual levels of mass reduction achieved between vehicles and even for estimating potential future mass reductions without consideration of costs (as in the approach taken in the ControlTec Load Reduction Study),[182] applying such a model to determining levels of mass reduction technology already applied can be problematic. (The distinction between technology level and mass reduction level achieved is important because it is the level of design optimization and lightweight technology application already implemented which determines the cost for additional future mass reduction, not the level of mass reduction achieved relative to the baseline of the cost curve or in comparison to other vehicles.) There are three key issues that arise with this approach: (1) the average curb weight (and therefore the zero mass reduction point) changes based on the model year chosen for analysis; (2) the method does not account for mass added associated with safety and other customer expected and desired features; and (3) a regression analysis cannot determine the actual level of materials selected relative to the position of those materials on the predicted direct cost curves.

In each subsequent model year, it is reasonable to assume that additional mass reduction will occur, thereby theoretically lowering the average curb weight predicted by a regression model. Over time, the zero residual values will become progressively lower. This will force the

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[180] *Id.* at 4-65 to 4-67.
[181] ControlTec Load Reduction Study, p. 49 et seq.
[182] *Id.* at 45 et seq.

estimated degree of mass reduction technology applied into progressively lower categories as can be observed with the Ford F150 example above. Theoretically, this problem can be avoided to some extent by developing the regression analysis on the baseline year associated with the cost curve. However, the other two additional issues identified cannot be addressed so easily and still have a significant impact on the accuracy of applying a regression model-based analysis to determine the level of mass reduction technology applied.

The Alliance recommends that alternative approaches be considered that could more accurately capture the level of mass reduction technology already applied relative to the developed cost curves.

Determination of Baseline Aerodynamic Drag Improvement Level

As described in Appendix B of these comments, EPA and NHTSA have pursued different paths for defining the initial aerodynamic state of the vehicles in their baseline fleets. Both of these methods give no consideration to vehicles that have already adopted aerodynamic improvements. This means that all vehicles are candidates for up to a 20% reduction in aerodynamic drag. An assumption that all vehicles are capable of 20% aerodynamic improvement, regardless of where the vehicle starts, will lead to an overly optimistic assessment of possible aerodynamic load reduction.

Determination of Baseline Tire Rolling Resistance

Section 5.2.6.1 of the Draft TAR reports on the state of tire technology.[183] That section notes that "low rolling resistance tires are increasingly specified by OEMs" yet neither Agency recognized that fact when defining their initial, baseline fleets. As a result, the Volpe and OMEGA models continue to apply low rolling resistance tire technology on top of what has already been specified by manufacturers.

NHTSA's MY2015 baseline fleet analysis contains no recognition of low rolling resistance tires (based on the market data file for the Volpe model show no "USED" classifications for ROLL10 or ROLL20).

EPA gives some credit to a limited number of vehicles but the application appears inconsistent. For example, the market data file contains two columns titled "Estimated Tire RRC" (column DS) and "Low Rolling Resistance Tires" (column EF). When filtering for vehicles that do NOT have low rolling resistance tires, the range of estimated tire RRC is 4.4 to 15.1. When filtering

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183 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, (EPA-420-D-16-900, July 2016) at 5-152.

for vehicles that DO have low rolling resistance tires, the range is 4.9 to 10.1. This wide overlap is confusing, should be explained, and may need to be revisited by EPA.

Clearly, some definition of low rolling resistance is required to specify which vehicles have already applied some level of this technology. The Alliance generally proposes the values used by Argonne National Labs in Table 5.219 in the Draft TAR.[184] We note that some additional consideration may need to be given to certain types of vehicles (e.g. high performance vehicles and those designed for off-road use) similar to what was done in the ControlTec Load Reduction Study. With these types of values, ROLL10/LRRT1 and ROLL20/LRRT2 can be defined. Table 3-1 below shows the reference Argonne values as well as the 10% and 20% target values.

Table C-1: Argonne National Labs Reference Rolling Resistance

	Small Cars	Midsize Cars	Small SUVs	Midsize SUVs	Pickups
Reference RRC	0.0075	0.008	0.0084	0.0084	0.009
ROLL10/LRRT1 RRC	0.00675	0.0072	0.00756	0.00756	0.0081
ROLL20/LRRT2 RRC	0.006	0.0064	0.00672	0.00672	0.0072

With these objective numbers, the baseline fleet of vehicles can be categorized according to their actual performance. The Alliance and its members could assist the Agencies with this update.

The Alliance also recommends the following refinements:

1. As with aerodynamics, the designation of rolling resistance reduction should be the center of the range instead of the start of the range. For example, a ROLL10/LRRT1 vehicle should be any vehicle that is 5% to 15% better than the reference value. This is consistent with NHTSA's method for mass reduction where a vehicle is considered to have 5% mass reduction (MR1) for the range of 3.75% to 5.625% below trend.

2. The Agencies should also consider reducing the step size from 10% to 5%. This will provide greater resolution in the results. Combined with the previous recommendation, the ROLL10/LRRT1 vehicle would range from 7.5% to 12.5% of the reference rolling resistance.

Other Technologies in the Baseline Fleet

As demonstrated for vehicle load reduction technologies (mass, aerodynamic, and tire rolling resistance), the assessment of the presence of certain technologies can be a challenge,

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[184] *Id.* at 5-503.

particularly when the technology is not a single component, but an implementation of various features, or masked by other competing factors. This is also the case for other technologies such as engine friction reductions, improved accessories, and certain transmission and driveline-related improvements. To the extent permitted within the Draft TAR comment period, and potentially following the close of the comment period, the Alliance expects that individual manufacturers will attempt to identify areas in which the Agencies have underestimated the level of technology deployment in their respective vehicles.

Other Concerns Regarding the Agencies' Baseline Discussion

In general, the Draft TAR Chapter 4[185] discussion of the baseline, reference, and control fleets is confusing and appears to be overcomplicated, and yet is still only based on a single year's worth of sales data from MY2014 projected out to MY2025. Also, it is unfortunate that the pull-ahead in timing of the Draft TAR resulted in using data even further in advance of MY2022-2025. The Agencies note that this can present a skewed picture as models enter and exit the market, which they believe works out over time. However, why is it not more appropriate to build a baseline fleet off a multi-year average as opposed to a single point in time? For example, EPA uses MY2014 as the baseline year, but applies MY2015 AEO2015 car/truck split assumptions. It is not clear if this is appropriate and if this is part of the reason that both the car/truck split and total vehicles sold values do not line up between the "Reference Case" and "Unforced Reference Case."[186] It is also difficult to compare baseline fleets between the Agencies when there is no alignment between the Agencies on the starting year. One of the more significant concerns is that the EPA did not present any interim projections when looking to MY2022, therefore the new forecasted picture between now and then is not clear.

The Agencies note that the reference fleet assumes all characteristics of individual vehicle models, except CO_2 emissions remain unchanged through MY2025. Therefore, the Agencies are assuming that any fuel efficiency technology added will not improve vehicle performance or utility.[187] However, this approach does not consider the case where technology added for fuel efficiency can degrade performance or utility, or that customers largely demand increasing performance and utility. The Alliance agrees that the potential tradeoffs between reducing CO_2 and improving other vehicle attributes deserves consideration, but the method should include more than reviews of limited modeling studies, and involve future work with automakers and customer research groups to focus instead on understanding the "hidden costs" associated with these technologies.

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[185] *Id.* at 4-1 et seq.
[186] *Id.* at 4-10, Tables 4.4 and 4.5.
[187] *Id.* at 4-26.

In the development of the reference fleet, EPA notes that, identical to their 2012 FRM analysis, they assumed the reference fleet will meet the MY2021 standards because gas prices were predicted to be stable through 2025, and the consequences of this were that only companies that build "lighter vehicles" would over-comply.[188] However, this fundamental assumption that gas prices would be stable was not correct. We suggest that the Agencies determine how this assumption affected the development of the reference fleet in MY2012 and what impact it could have on the current reference fleet assumptions. Further, we suggest that the Agencies considered the impacts of other regulations that affect CO_2 in the development of the reference and baseline fleets.

The Agencies discuss the idea that industry will not act absent regulations that will drive "major innovation,"[189] but do not appear to recognize that the industry innovates in many areas–not just in fuel economy–and that not all automakers innovate with the same focus. It is this diversity that has resulted in today's highly advanced vehicles that continually provide improved safety, features, and utility. It has also resulted in major innovations in areas like autonomous driving, which can also impact fuel efficiency of the fleet. Further, the Agencies should recognize that relying on best-in-class technology improvements for the entire fleet could be problematic where patents may protect certain unique innovations.

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[188] *Id.* at 4-26.
[189] *Id.* at 6-8.

Appendix D: Cost Optimization Modeling (OMEGA / Volpe Model)

As was previously discussed in these comments, the Alliance believes that the Agencies have underestimated the technologies and costs required for compliance.

The limited time available to assess the Draft TAR has prevented the Alliance from preparing in-depth comments on the specific methods and constraints applied by the Agencies in their OMEGA and Volpe Models. However, we offer these preliminary comments and may choose to submit supplemental comments regarding these models at a later date.

Upstream GHG Accounting

In its OMEGA modeling, EPA has assumed zero upstream (i.e. electric utility provider) emissions for battery electric vehicles and the electric portion of operation for plug-in hybrid electric vehicles. Although the Alliance agrees that zero upstream emissions is appropriate,[190] under the current regulation manufacturers that exceed certain production thresholds of advanced technology vehicles are required to add upstream emissions. This accounting degrades the compliance benefits of plug-in electric vehicles by raising the calculated tailpipe CO_2 value. The Alliance recommends that EPA analyze the sales of advanced technology vehicles modeled for each manufacturer and determine if any manufacturer is projected to exceed the production thresholds for the 0 g/mi advanced technology vehicle incentive. If a manufacturer is modeled as exceeding the applicable thresholds, then EPA should include the negative impact of upstream GHG accounting in its analysis unless and until upstream emission accounting is removed from the rule.

Response to EPA Sensitivity Analysis

In Section 12.1.2 of the Draft TAR,[191] EPA provides a number of sensitivity analyses. In its observations based on these sensitivity analyses, EPA notes that fuel prices have little impact on the cost per vehicle outcomes, little impact on the technology penetration outcomes, and do not result in substantially different fleet electrification.[192]

The EPA's sensitivity analysis in regards to fuel prices is fundamentally flawed. EPA notes that the primary difference in the OMEGA modeling caused by the change in fuel price is a shift between car and truck fleets. What the Agency fails to consider is that in developing the reference and control case fleets, once the car and truck fleet splits are established, only minimal

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[190] *See* Alliance comments at Appendix G for additional detail.
[191] 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, (EPA-420-D-16-900, July 2016) at 12-36 et seq.
[192] *Id.* at 12-40.

differences would be expected from the OMEGA model. This is because it does not consider customer choice and iteratively modify the subsequent vehicle and powertrain selection characteristics. The EPA's analysis does not account for the market moving away from (or toward) higher efficiency powertrains to (or from) lower efficiency powertrains in the same vehicles. Nor does the EPA analysis account for market shifts within the passenger car segments (which are more closely aligned with the footprint-based target curve) to (or from) compact and mid-size utility vehicles (which are generally more challenged to meet the passenger car target curve). If these market shifts were also considered (and not just a general car fleet versus truck fleet shift), the sensitivity to fuel price would likely be much higher. The Alliance recommends that the Agencies develop or purchase a full customer choice model which takes issues such as those described above into account.

Appendix E: Economic Considerations: Customer Acceptance

Introduction

It is clear that both NHTSA and EPA are obligated to take economic considerations into account as part of the MTE, as both Agencies have statutory obligations in this regard. In NHTSA's case, the Energy Policy and Conservation Act[193] specifies that, in determining the "maximum feasible average fuel economy" for a given model year, NHTSA must consider four factors, one of which is "economic practicability."[194] There is a long history of NHTSA rulemakings on fuel economy standards in which NHTSA has discussed the meaning of the "economic practicability" criterion and applied its interpretation of that criterion in making decisions about fuel economy standards. Section 202(a)(2) of the Clean Air Act also requires EPA to take economic factors into account in setting standards applicable to the emission of air pollutants, stating that EPA must give "appropriate consideration to the cost of compliance" with its standards in light of the amount of lead time allotted for compliance.[195]

In addition to these statutory requirements, it is also clear that the MTE regulations themselves require a robust consideration of economic issues prior to the issuance of a final determination. The light-duty vehicle greenhouse gas regulations set forth a list of factors that EPA must consider as part of the MTE process, including at least two factors that are unmistakably "economic" in nature: "[t]he cost on the producers or purchasers of new motor vehicles or new motor vehicle engines," and "[t]he impact of the standards on the automobile industry."[196] Moreover, the preamble to the final rule setting the MY2017 and beyond GHG and CAFE standards made it clear that EPA will consider a range of economic factors as part of its decision-making process:

> The decision making required of the Administrator in making that determination is intended to be as robust and comprehensive as that in the original setting of the MY2017-2025 standards. In making this determination, EPA will consider information on a range of relevant economic factors, including but not limited to those listed in the rule and below:
>
> ***
>
> 2. Impacts on employment, including the auto sector.
>
> ***

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[193] 49 U.S.C.A. § 32902(f).
[194] *Id.*
[195] 42 U.S.C.A. § 7521(a).
[196] 40 CFR § 86.1818-12(h).

5. Costs, availability, and customer acceptance of technologies to ensure compliance with the standards, such as vehicle batteries and power electronics, mass reduction, and anticipated trends in these costs.

6. Payback periods for any incremental vehicle costs associated with meeting the standards.

7. Costs for gasoline, diesel fuel, and alternative fuels.

8. Total light-duty vehicle sales and projected fleet mix.

9. Market penetration across the fleet of fuel efficient technologies. [197]

All of the factors listed immediately above relate to the economic impacts of the proposed GHG standards(with the exception of item 2 above--employment impacts, which will be the subject of Appendix F) and these items implicate customer acceptance of vehicles meeting the MY2022-2025 standards.[198]

Customer acceptance is, therefore, a complicated subject. At the most basic level it depends on the vehicle attributes that customers value. Customers value fuel economy, but they also have other requirements. Is the vehicle large enough to fit their family? Does it offer the right features, handle well in inclement weather or poor road conditions, and provide sufficient towing and payload capability? Most importantly, can the customers afford it? The numerous errors made in defining the baseline fleet, coupled with the selection of optimistic data for assessing the effectiveness and costs of future technologies, give reason to conclude that the MY2022-2025 standards will require dramatic marketplace changes that customer are not currently prepared to accept.

The 2012 FRM emphasized that an analysis of customer acceptance was vital to the assessment of whether the MY2022-2025 GHG and CAFE standards were appropriate.[199] Last year, however, the Agencies made a decision to accelerate the timing of the Draft TAR. This means sufficient data as to the effectiveness of the MY2017-2021 program – including data on customer response- is not yet available, because the program has not yet taken effect. Instead, the

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[197] 77 Fed. Reg. 62784 (Oct. 15, 2012).

[198] The Alliance recognizes that the Draft TAR is a technical assessment rather than a decision document, and that the agencies' final MTE determinations will be based on a body of information that is larger than the Draft TAR. Thus, the Draft TAR may not contain all of the material that the agencies will use to draw conclusions on the economic impacts of the CAFE and GHG standards, as required by the various statutory and regulatory provisions outlined above. Having said that, we understand that the Draft TAR contains the bulk of the data and analyses that the agencies plan to rely upon for their final decisions. If so, it is clear that the information set forth in the Draft TAR is insufficient to support the economic determinations that the agencies will be required to make.

[199] 77 Fed. Reg. 62784 (Oct. 15, 2012). See generally the description of the mid-term evaluation and inclusion of customer acceptance as a relevant factor.

Agencies are focused on the impact of the MY2012-2016 standards which neither require the same stringency nor are representative of the cumulative effects of the regulation as a whole. It is not reasonable to expect that customers will react the same in MY2022 - 2025 as they have through MY2016 in response to the changes to the fleet required by the Agencies.

The importance of conducting meaningful research to help better understand customer acceptance has been echoed by many organizations. Recently, a committee of experts completed a 30-month study under the direction of the National Research Council (NRC).[200] After hearing expert testimony, reviewing the literature, and engaging expert panelists, the NRC issued a final report that included the following recommendations:

> **Recommendation 9.1** The Agencies should do more research on the existence and extent of the energy paradox in fuel economy, the reasons for consumers' undervaluation of fuel economy relative to its discounted expected present value, and differences in consumers' perceptions across the population.
>
> **Recommendation 9.2** The Agencies should conduct more research on the existence and extent of supply-side barriers to long-term investments in fuel economy technologies.
>
> **Recommendation 9.3** The Agencies should study the value of vehicle attributes to consumers, consumer willingness to trade off other attributes for fuel economy, and the likelihood of consumer adoption of new, unfamiliar technologies in the vehicle market. This will enable the Agencies to better understand consumer response to the CAFE rules and better assess the rules' costs and benefits.[201]

Notwithstanding the central importance of this issue, less than 30 pages of the 1,200 page Draft TAR are dedicated to evaluation of customer acceptance. After providing a cursory literature review, the Agencies conclude that they cannot make any significant conclusions.

We urge the Agencies to revisit this critical topic to ensure that the regulations they deem "technically feasible" do not result in market failures and subsequent economic impacts. The customer acceptance challenges of meeting the MY2022-2025 standards are real and need to be dealt with in the MTE. To perform an appropriate cost-benefit analysis, the Agencies must address a wide variety of customer acceptance concerns. If the standards are out of line with the market they will not be met.

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[200] "Cost, Effectiveness and Deployment of Fuel Economy Technologies for Light-Duty Vehicles." National Academy of Sciences, National Research Council to the National Academies. 2015.
[201] *Id.* at 333-334.

Without the tools to understand customer response, the Agencies will not be able to understand the current situation with its lower fuel prices, much less the more complex aspects of customer acceptance. Such factors include the effect on customers who could either be priced out of the new car market or who fail to find vehicles with attractive attributes and features; the possible loss of environmental benefits as older vehicles remain in the field longer and are not replaced by newer, cleaner and more efficient models; and the potential financial effects on automakers and their employees who could face significant penalties and investment loss if higher cost, low-emitting vehicles are rejected by customers.

Even in the Current Environment, Low Fuel Prices Have Retarded Acceptance of High Technology Vehicles

Even in the current market of record-breaking vehicle sales, the majority of customers are not adopting the most advanced technology or efficient vehicles. The Alliance believes one primary factor is low gas prices. The assumptions about gas prices that the Agencies relied upon in the 2012 FRM deserve examination. The ONP was launched with an expectation of structurally high gas prices but is unfolding in a period of sustained lower gas prices, profoundly impacting customer choice. In the Agencies' original analysis in the 2012 FRM, they predicted gas prices would be $3.87 in 2010 dollars by 2025, or about $5 a gallon. This assumption was made when fuel prices were at their highest level in the past 40 years, exceeding those of the late 1970's and early 1980s.[202]

When gas prices fall, especially in the context of improving mileage across segments of the market, the desire to walk out of the showroom with a hybrid (or other alternative powertrain) diminishes (Figure E-1).

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[202] "Short-Term Energy Outlook." U.S. Energy Information Administration. Accessed September 21, 2016. http://www.eia.gov/forecasts/steo/realprices/.

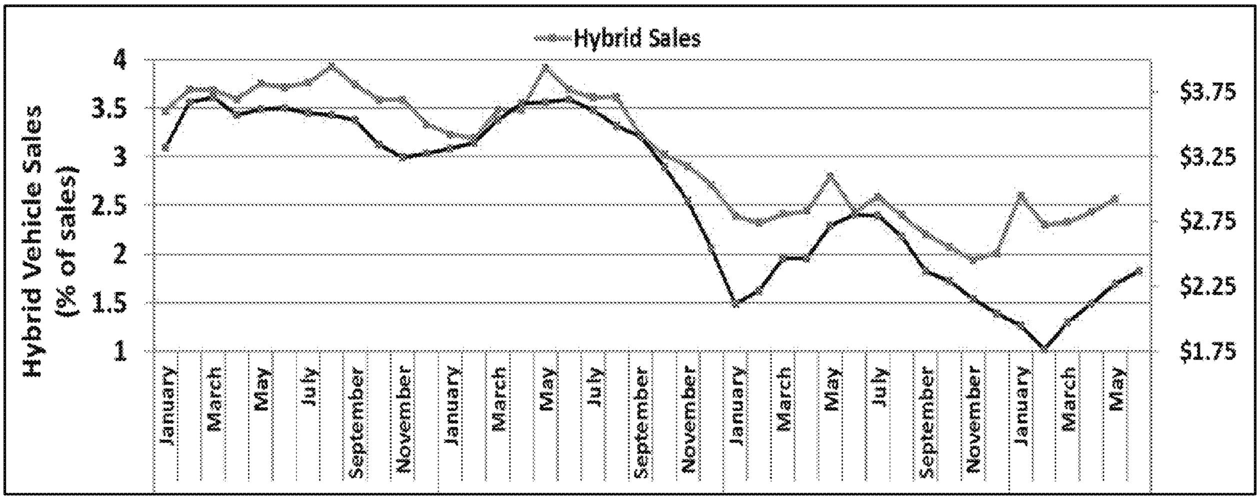

Figure E-1: Retail Market Share of Hybrids and Gas Prices, 2013-2015

Some would point to the attribute-based (i.e. footprint) CAFE requirements for cars and trucks as a complete solution to counteract any shifts in customer choice due to low gas prices. Although attribute-based standards help ensure the entire fleet improves regardless of large shifts in demand, customers still choose how much they are willing to spend on features other than fuel efficiency improvements *within the same vehicle platform* (even within the same footprint and class). Often *within a model*, customers demand options for different levels of performance and features that affect FE and GHG emissions. For example, customers are overwhelmingly choosing to purchase a model with a conventional powertrain in lieu of that same model with a hybrid electric powertrain – over 92% of customers purchase the conventional powertrain when a choice is available.[203] Additionally, customers are moving from sedans to car-based sport utility vehicles that have similar footprints but greater utility and lower fuel economy. As a result, achieving FE targets even within a particular vehicle footprint/platform depends on customers' willingness to pay for the greater FE options within that platform. We believe that the EPA and NHTSA incorrectly assume via the Draft TAR that customers will make such vehicle efficiency decisions irrespective of the costs involved.

What Will It Take to Achieve the Future Requirements?

The Agencies are correct in finding that automakers are meeting the current GHG and CAFE standards. In the early years of the program, automakers succeeded in significantly increasing FE by rapidly deploying a variety of near-term technologies that can improve mileage while keeping

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[203] Calculated from data provided R.L. Polk & Co. Retail sales of sedans and SUVs offered as either gas-powered or hybrid, January 1, 2015 through May 31, 2016.

new vehicles affordable. In its most recent Light-Duty Vehicle Fuel Economy Trends Report,[204] EPA found that more than 98% of new vehicles now incorporate variable valve technology while more than 85% of new vehicles have an advanced transmission (dual clutch transmission, continuously variable transmission, or 6+ speeds).[205] It is important, however, to note that some manufacturers could be using over-compliance as a strategy to bank credits for future, more stringent standards. Automakers have also moved with startling speed to add alternative powertrain options. In MY2015, this included 46 models of hybrids, 18 electric models and 12 plug-in hybrids, plus literally hundreds of new high-MPG gas and diesel offerings.[206] The industry's innovations have also resulted in a fast-growing selection of energy-efficient models. According to www.fueleconomy.gov, the number of models achieving EPA label ratings of 30 MPG or higher highway fuel economy has grown by over 700% since 2006, while the number of models achieving 40 MPG or more has increased tenfold over the same period (Figure E-2).

	30+ MPG	40+ MPG
2006	69	7
2007	76	2
2008	113	5
2009	149	8
2010	204	13
2011	235	20
2012	299	34
2013	405	50
2014	450	66
2015	495	76
2016	509	80

Figure E-2 Number of Vehicle Models Exceeding 30 and 40 MPG Based on EPA Highway Fuel Economy Rating[207]

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[204] "Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 Through 2015." Environmental Protection Agency. EPA-420-R-15-016. 2015. Accessed September 17, 2016. https://www3.epa.gov/fueleconomy/fetrends/1975-2015/420r15016.pdf.

[205] *Id.*

[206] Accessed September 26, 2016. www.FuelEconomy.gov

[207] *Id.*

The MY2022-25 Standards Represent an Unprecedented Challenge

Going forward, we know that manufacturers will continue to implement technologies to further FE and reduce GHG emissions. What is uncertain, however, is whether it is realistic to expect that customers will purchase the vehicles that achieve fuel efficiency gains that are sufficient to satisfy the GHG standards and CAFE standards for MY2022-2025 or to cover any gaps originating through MY2021 as a result of lower gas prices or economic conditions. The target schedule assumes efficiency gains of about 5% per year for cars and about 3.5% per year for trucks during the MY2012-2021 portion of the program.[208] The four subsequent years impose an expectation of efficiency gains of about 5% per year for both cars and trucks. As the chart below illustrates, the road ahead is steeper. Note, that although the CO_2 grams per mile reductions would be more linear, the fuel economy curve better highlights the increasing difficulty, or asymptotic difficulty, in approaching zero CO_2 g/mi emissions and higher fuel economy. (Figure E-3).

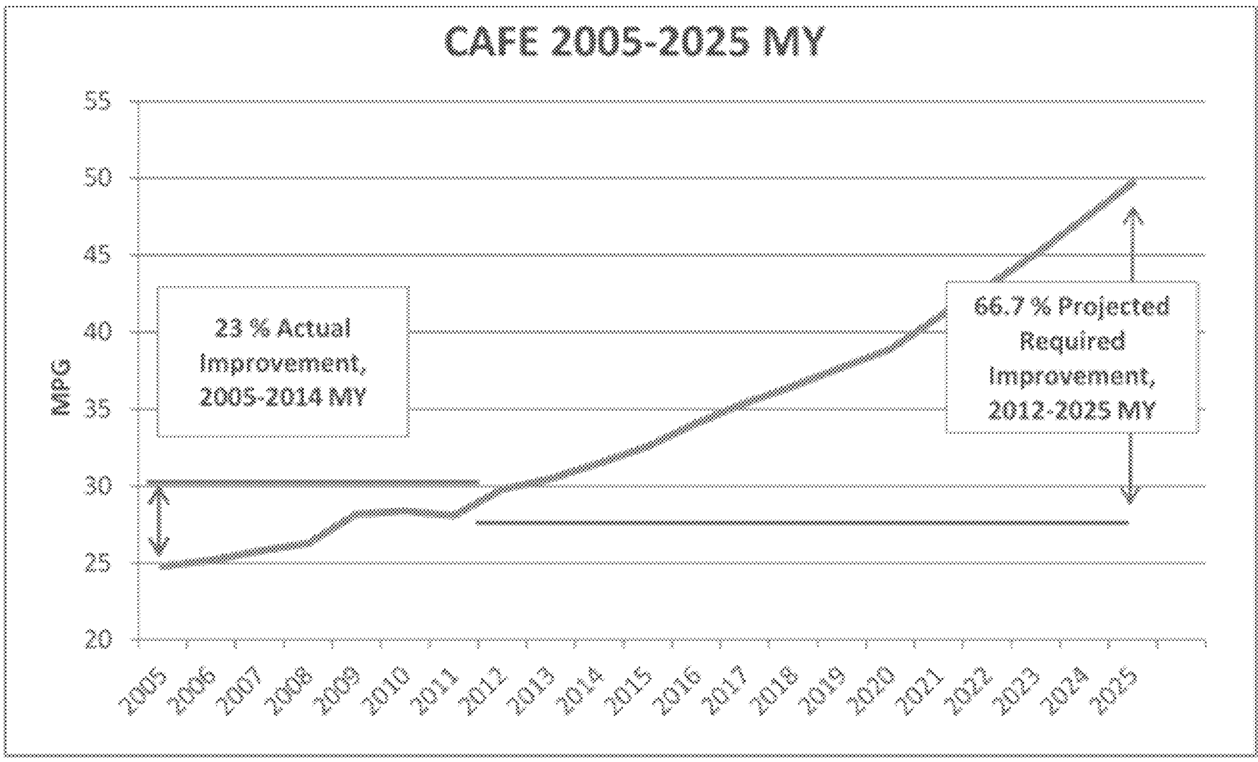

Figure E-3 Historical and Projected Industry Fleet Average CAFE Standards (MY2005-2025)

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[208] Significantly, the compliance path for "cars" becomes more difficult in the out years as the trend away from sedans to car-based CUVs continues. CUVs have customer desired attributes but a more difficult compliance path than sedans.

One way to further illustrate this challenge is to consider what would need to occur with each major model redesign. The estimated average production life for a freshly redesigned vehicle ranges from 4.5 to 9.7 years, with most vehicles in the 5- to 7-year range.[209] (Trucks tend to have the longer redesign ranges.) This means that a car redesigned in MY2025 would need to achieve a 25-35% improvement in fuel economy; a truck redesign in MY2025 would need to achieve a fuel economy increase of 22.5-29%.

Citing the recent Light-Duty Vehicle Fuel Economy Trends Report, the Agencies point to automakers' current compliance with the CAFE and GHG standards as proof of the efficacy of the future GHG and CAFE standards.[210] In this case, however, past compliance is a poor barometer for measuring future ability to comply. The key question is not *whether* the manufacturers have complied thus far, but *how* this has been achieved.

One way that manufacturers have kept ahead of the requirements is by quickly introducing new fuel-saving technologies. In its Light-Duty Vehicle Fuel Economy Trends Report,[211] EPA reported that variable valve timing and multi-valve engines would be used in all MY2015 vehicles and noted that gasoline direct injection and turbocharged engines had increased five-fold since MY2010. EPA also noted significant increases in transmissions of six or more speeds and continuously variable transmissions (CVT).[212]

By quickly introducing these changes, however, the manufacturers are drawing from a limited pool of proven near-term technologies that they will soon exhaust. The Agencies express confidence in the continuing rapid pace of technology deployment, but seem to disregard the delta between available and relatively inexpensive technology and longer-term pathways that are recognized to cost more and come with greater customer acceptance hurdles.

Another way manufacturers have kept up with increasingly stringent CAFE and GHG standards is by making use of certain credit-generating mechanisms. These mechanisms, which were part of the agreement reached between the Agencies and the manufacturers, have provided appropriate credit for past investments and awarded manufacturers for accelerating the deployment of advanced CO_2 reducing technologies earlier than expected. Credits for CO_2-reducing technologies were supported by all stakeholders as an appropriate part of the ONP. The significant and early use of credits by manufacturers that have elected to invest in these technologies reflects individual choices driven by unique business plans and ongoing

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[209] 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, (EPA-420-D-16-900, July 2016) at 4-57, Table 4.42.
[210] *Id.* at 3-2.
[211] "Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 Through 2015." Environmental Protection Agency. EPA-420-R-15-016. 2015.
[212] *Id.*

assessments of technology pathways. This is equally true for manufacturers that have elected to engage in credit trading with other producers. Trading was supported by the Agencies as a means to achieve cost-effective compliance. Manufacturers again will continue to assess trading relative to investment in technology.

While credits are a welcome and appropriate part of the ONP, the significant use of credits by some manufacturers is also a sign of their struggles to meet the pre-MY2022 standards, indicating potential longer-term issues. This is especially true for manufacturers that have relied on credits purchased from other companies, since there is no guaranteeing that today's credit suppliers will continue to generate or sell surplus credits. Even assuming there are manufacturers in the market with credits they are willing to sell, credit costs are bound to increase as manufacturers complete the deployment of near-term technologies and begin needing to deploy costlier changes.

The MY2022-2025 Standards Require Dramatic Marketplace Changes

In the Draft TAR, the Agencies point to past over-compliance and a growing range of fuel-efficient technologies, expressing a preliminary view that automobile manufacturers can meet or exceed both the GHG standards currently in place and the CAFE standards. One way to assess the Agencies' expectations is to examine the percentage of MY2015 vehicles that meet future CO_2 emission targets. The Agencies have said that the MY2025 compliance does not require significant hybridization or electrification, but that seems to reflect a leap of faith that transcends current technology realities. The results as shown in Figure E-4 are intriguing: EPA reports that 22% of MY2015 vehicles operating on diesel or gasoline meet the MY2018 CO_2 emissions targets or can do so with the addition of expected air conditioning improvements. Future MPG targets are so high that fewer than 4% of current models meet MY2022 targets, and the sales of these most energy-efficient vehicles remain low. Currently, *no* diesel or gas (non-hybrid) vehicles make the MY2025 target.

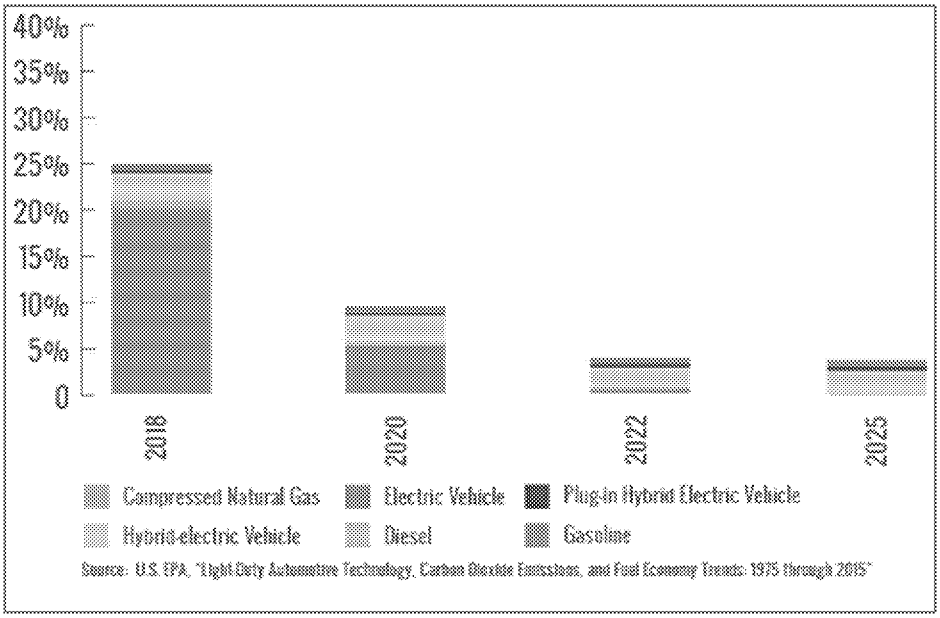

Figure E-4 MY2015 Vehicle Production that Meets Future Greenhouse Gas Targets

A recent analysis by Novation Analytics, further illustrates this concern (attached as Attachment 5).[213] Novation Analytics found that manufacturers will need to apply more technologies than were predicted by the 2012 FRM as needed to meet projected targets, and that the post-MY2021 standards cannot be achieved without significantly higher sales of advanced technology vehicles, including HEVs, PHEVs, and BEVs.

The Novation Analytics analysis, which relies on EPA and NHTSA data, has been shared with the Agencies. It finds that certain milestones need to occur in order for manufacturers to meet the MY2022-2025 standards:[214]

- by 2021, the fuel economy performance of the entire fleet will need to equal today's most efficient gasoline vehicles;
- by 2021, vehicle loads will need to be reduced by 1% annually (by reducing mass, improving aerodynamics and adopting low rolling resistance tires); and
- by 2025 the entire fleet will need to achieve the 10% load reduction and exceed the fuel efficiency of today's most efficient gasoline powertrains.

Novation Analytics concludes, "[m]oving the entire industry to the current best spark-ignition (SI) powertrains would provide compliance only to MY2020. Advanced SI technologies,

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[213] "Trade Association Studies; Powertrain Technology Effectiveness, Phase II." Novation Analytics. Technical Briefing. May 17, 2016. Accessed September 21, 2016.
[214] *Id.*

unproven in production, and/or high rates of electrification will be required by MY2025."[215] See Figure E-5.

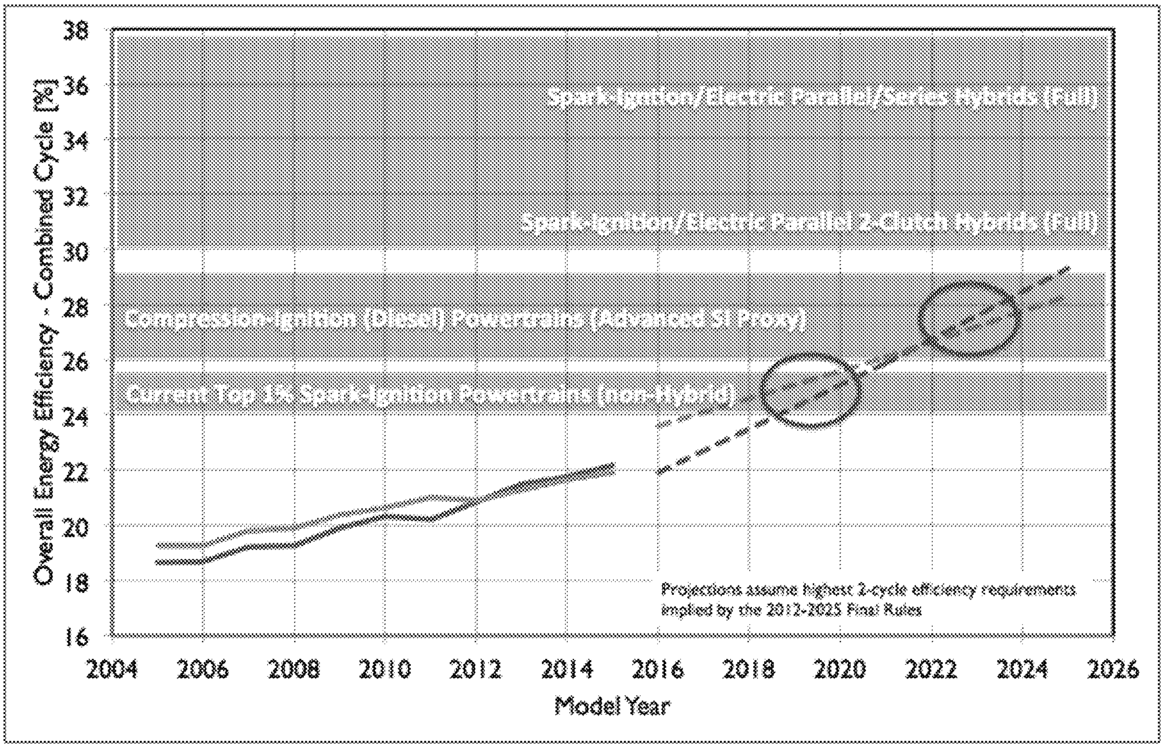

Figure E-5: Overall Powertrain Energy Conversion Efficiency Implied by the GHG and CAFE Standards and Exemplar Technologies to Achieve These Efficiencies[216]

What Customers Are Doing in the Marketplace

A key component of the MTE should be an assessment of what customers are doing in the marketplace.

As we move further into the target schedules, one of the great unknowns that is critical to meeting the future standards is the adoption rate of alternative powertrains. As Figure E-6 below illustrates, customers today overwhelmingly choose gas-powered engines over alternative powertrains.

[215] *Id.*
[216] *Id.*

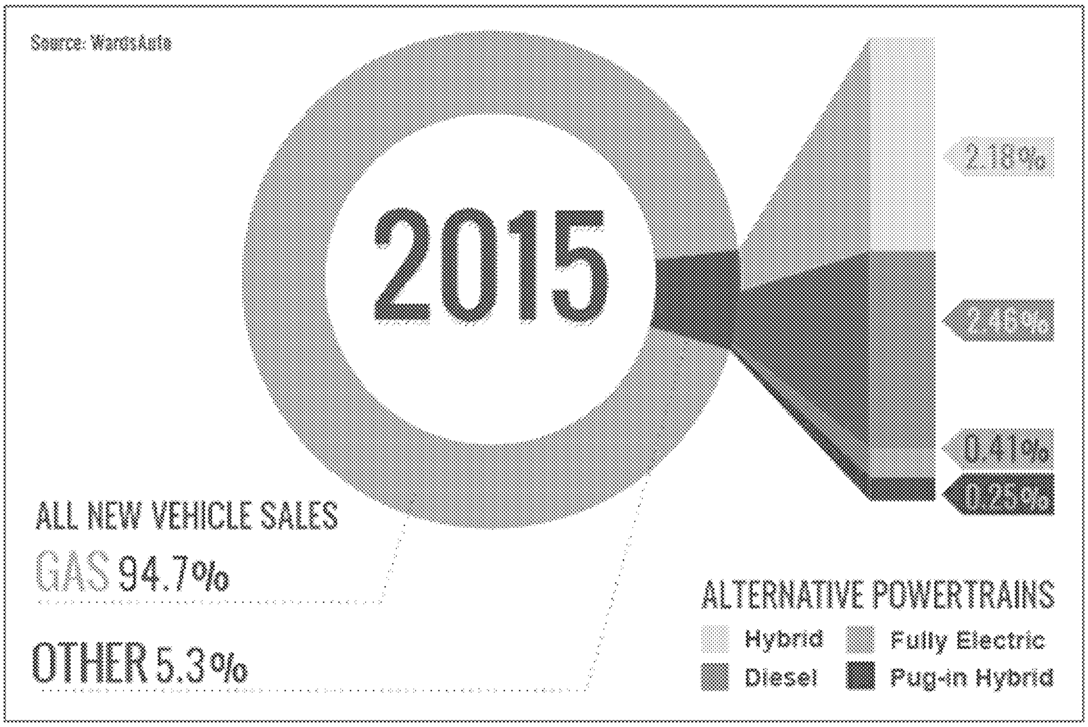

Figure E-6 MY2015 Powertrain Selection by Customers

Two possible explanations for the strong preference for ICEs are customers may be more familiar with gas-powered engines,[217] and that customers are satisfied with the fuel economy provided by gas-powered engines.[218] Further, even in the face of higher gasoline prices, the absolute benefit in cost savings and miles per gallon improvement of each percent of increase in fuel economy diminishes. This is called "MPG illusion", in which car buyers overvalue fuel economy increases for high-mpg vehicles relative to low-mpg vehicles. Figure E-7 illustrates the issue.

[217] This despite the presence of advanced electrified technologies in the market for over a decade.

[218] As fuel economy from conventional powertrains increases, the Alliance believes that some customers have become satisfied with their current level of fuel economy and do not wish to pay the premium to move to more advanced technologies.

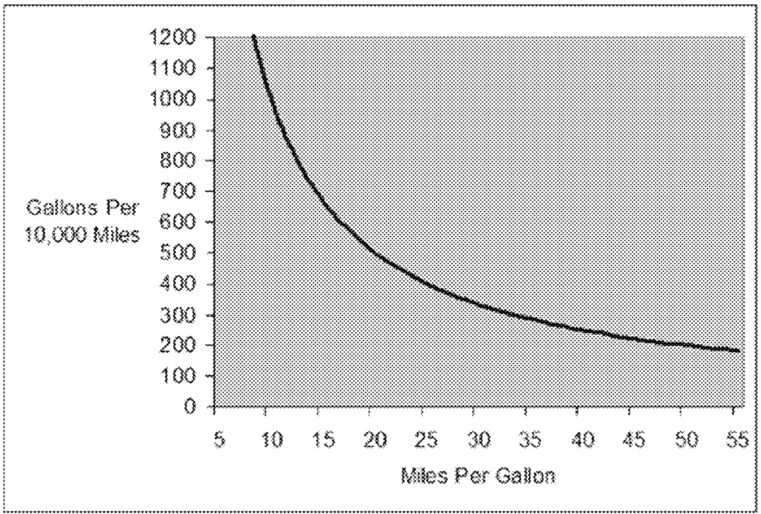

Figure E-7: As Miles per Gallon Increase, Resulting Reductions In Fuel Consumption Decrease[219]

In the Draft TAR, the Agencies state that "[i]t is difficult, if not impossible, to separate the effects of the standards on vehicle sales and other characteristics from the impacts of macroeconomic or other forces on the auto market."[220] Nevertheless, the Agencies predict that customers will accept the technologies needed to meet the future standards and will be willing and able to pay added vehicle costs. The Agencies thereby sidestep critical customer research--most notably, the post-purchase survey data that the National Research Council called "the most reliable information about consumer preferences"[221]--and rely instead on statements made by professional auto magazine reviewers.

Rather than using the tools at hand to attempt to predict customer behavior, the Agencies have put customer purchasing behavior in the "too hard" bucket, sidestepping this critical issue. The Agencies, thereby, would lack a basis for a conclusion that customers will accept the technologies needed to meet the future standards in a manner that will enable the manufacturers to comply at an affordable cost.

Customer choice is complex; for over 100 years automakers have attempted to understand and predict it, but nonetheless, it is important to work to get the best possible insight on this tricky issue. The 2015 NAS report on fuel economy technologies concluded that the best possible insight on future customer decision-making comes from customers themselves.[222] The panel

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[219] The MPG Illusion. Accessed September 26, 2016. http://www.mpgillusion.com/.

[220] 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, (EPA-420-D-16-900, July 2016) at 6-1.

[221] "Cost, Effectiveness and Deployment of Fuel Economy Technologies for Light-Duty Vehicles." National Academy of Sciences, National Research Council to the National Academies. 2015. 325.

[222] *Id.*

referred to the New Vehicle Experience Survey (NVES) conducted by Strategic Vision, a study involving more than 300,000 recent new car buyers annually, as “the most reliable information about consumer preferences.”[223] The most recent NVES (see Figure E-8) shows that fuel economy, although important, is not a top purchasing reason for new car buyers.

Rank	Attribute / Purchase Reasons	Percent
1	Overall Safety of the Vehicle	64%
2	Overall Driving Performance	63%
3	Safety Features	62%
4	Front Visibility	60%
5	Braking	59%
6	Overall Value for the Money	58%
7	Price/Deal Offered	57%
8	Overall Impression of Durability/Reliability	56%
9	Riding Comfort	54%
10	Comfort of Front Seat	54%
11	Handling	53%
12	Rear Visibility	53%
13	Warranty Coverage	53%
14	Road Holding Ability	51%
15	Engine Performance	50%
16	Affordable to Buy	50%
17	Haul Cargo in Bed	50%
18	Fun To Drive	50%
19	Overall Seat Comfort	50%
20	Maneuverability	48%
21	Overall Thoughtful Engineering	48%
22	Past Experience With Brand	47%
23	Driver Seat Adjustability	47%
24	Overall Experience with Selling Dealership	47%
25	Front Seat Roominess	47%
26	**Fuel Economy/Mileage**	**46%**
Source: NVES 2016 Survey		

Figure E-8 Vehicle Buyer Purchase Reasons[224]

After reviewing NVES results, the NRC panel concluded that, “…while consumers value fuel economy, they do so in the context of other attributes they also value… they look for the most

[223] Id.
[224] Strategic Vision New Vehicle Experience Survey.

fuel-efficient version of a vehicle they already want to purchase… Consumers are buying fuel efficient versions of vehicles that suit their wants and needs."[225]

The Agencies have not attempted to identify the impacts of the MY2012-2016 standards on prices and affordability or to predict what the future standards will mean for customers. They conclude that, in the long run, customers will benefit, but never show how, or at what rate, the technologies required to meet the MY2022-2025 standards will be purchased. The Agencies are, in essence, suggesting that they are not prepared to perform a cost-benefit analysis before moving forward with a program costing billions of dollars. Ultimately, to avoid arbitrary conclusions or decision-making, the Agencies should consider analyses directly relevant to customer acceptance and the impact of customer acceptance on the industry.

Anticipated Payback Periods Far Exceed Customer Tolerance for Higher Vehicle Prices

One specific concern that must be addressed in the NPRM and the proposed determination is the wide gap between the payback periods that customers find acceptable and those anticipated by the Agencies. The Draft TAR defines payback period as "the number of years of the accumulated dollar value of fuel savings needed to recover the additional cost of technology included in the purchase price of a new vehicle."[226] EPA's analysis (not taking into account payback for costs related to the ZEV Program) concludes that the MY2025 standards will result in increased vehicle costs that customers will, on average, recover in 5 to 5 ½ years. NHTSA's analysis indicates a payback period of about 6 ½ years.

In its recent review of the CAFE standards, the NRC panel looked at the leading economic research on payback periods. The panel also met with individual manufacturers to receive their input on what customers consider an acceptable payback period. The panel found strong, consistent evidence that customers are typically willing to incur additional vehicle costs for fuel saving technologies that pay for themselves within 2-3 years.[227]

The disparity between the payback periods anticipated by the Agencies and those that customers will tolerate raises important questions regarding long-term viability of the new car market. If customers are unwilling to make up-front investments in technologies that take five or six years to pay for themselves, sales will drop. Faced with reduced profitability, manufacturers will take longer to recover their investments and have less money to invest in new technologies.

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[225] "Cost, Effectiveness and Deployment of Fuel Economy Technologies for Light-Duty Vehicles." National Academy of Sciences, National Research Council to the National Academies. 2015. 327.
[226] 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, (EPA-420-D-16-900, July 2016) at 13-97.
[227] "Cost, Effectiveness and Deployment of Fuel Economy Technologies for Light-Duty Vehicles." National Academy of Sciences, National Research Council to the National Academies. 2015. 317.

Automakers Have Limited Tools to Drive Customer Acceptance

Customer response to fuel efficient vehicles and technology offerings, such as fuel efficient powertrains and optional equipment, is a critical component of the CAFE and GHG standards. Manufacturers have a limited set of tools to drive customer acceptance of a vehicle fleet that is compliant with the standards, including vehicle pricing, marketing, and limiting sales of performance powertrains or even vehicle lines.

Pricing has limited capability to drive customer acceptance, however, especially in a low fuel-price environment. As previously mentioned, customers have a wide variety of preferences and functional requirements for their vehicles, which can include performance requirements, cargo and passenger capacity, comfort, and aversion to new technologies that do not have a significant history in the marketplace. Further, discounting prices in an attempt to induce sales is not a sustainable market approach.

Marketing campaigns across the industry commonly feature fuel economy as a competitive differentiator. Automakers prominently advertise the fuel efficiency of their products and promote their fuel efficient technologies such as Ford's EcoBoost, the Chevrolet Volt, GM Ecotec, BMW EfficientDynamics, or Mercedes-Benz BlueEFFICIENCY.

In Chapter 6 of the Draft TAR,[228] the Agencies state that "development and uptake of energy efficiency technologies lags behind adoption that might be expected [as result of possible technology payback]" but this statement is inconsistent with Chapter 3 of the Draft TAR which states "[s]ince the promulgation of the 2017-2025 final rulemaking (FRM) in 2012, the automotive marketplace has undergone many changes. New vehicle sales, fuel economy, and horsepower are all at record highs. Many new technologies have been quickly gaining market share, gasoline prices have dropped by more than a third, and truck share has been increasing."[229] It is important that the Agencies recognize the significant technology push automakers have attempted as a result of this program, and that there are more highly efficient vehicles choices than ever available to customers. Two main types of technologies have been brought to market:technologies that require a trade-off in cost / efficiency / utility / performance (e.g. certain electrification technologies) and those with a good cost/benefit tradeoff that do not require customers to choose between the two.

Finally, if customer uptake of fuel efficient vehicles and technologies proves to be insufficient, manufacturers could face the prospect of limiting volume for powertrain options or vehicle lines that negatively impact fleet averages, or even eliminating certain offerings. This approach would

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[228] 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, (EPA-420-D-16-900, July 2016) at 6-1 et seq.
[229] *Id.* at 6-5, 3-2.

limit customer choice and reduce the utility of affected vehicles. In addition, such a scenario would likely lead to inequities in the market and ultimately market disruption if all companies were not forced to use the same strategy.

Positive Professional Auto Reviews Do Not Equate to Customer Acceptance

The Agencies have based their customer acceptance review on a study that relies on the opinion of auto magazine articles and the technology reviews they contain to determine whether or not there are significant problems with the uptake of fuel efficiency technologies. It is not clear if this group of reviewers appropriately represents the average customer's view of fuel efficiency technologies as these magazines often specialize in reviewing performance cars and are more accepting of and familiar with advanced technology. For example, *Car and Driver*'s "10 Best" cars of 2016 includes seven performance cars, and zero fuel efficient models; *Automobile* magazine's "2016 All Stars" includes only performance cars. *Motor Trend* identifies just one "Car of the Year" each year and for the last five years, has not chosen a fuel efficient vehicle. In 2011, when the Chevrolet Volt was released, they did choose the Volt as "Car of the Year" while noting in the review (regarding one of the judges in 2011) "[l]ike all of us on the staff at *Motor Trend*, Chris is an enthusiast, a man who'll keep a thundering high-performance V-8 in his garage no matter how high gas prices go. But he nailed the Volt's place in automotive history: 'If this is the brave new world, then it's an acceptable definition.'" It is also unclear if strong conclusions can be made from the sample size studied as only 30% of the technologies are shown to have over 100 evaluations.

One additional concern is the conclusion that if the number of positive evaluations exceeds negative evaluations, the technology is not problematic. For example, the Agencies discuss the two technologies that received the most unfavorable reviews, continuously variable transmissions (51% positive) and stop-start (59% positive) and conclude that "these results suggest that it is possible to implement these technologies without significant hidden costs" (where hidden costs indicate negative customer acceptance). However, it must be noted that in the highly competitive automotive market, it is not always acceptable to use a technology that only half of customers view positively and expect to remain competitive and successful.

The Agencies also state that as the data suggests it is possible to implement new technology and avoid hidden costs, automakers should also be able to improve implementation of these technologies over time.[230] However, as the level of standards increase yearly, there is not significant time to fully vet certain technologies or improve on them before they must either be replaced with something different or supplemented. This cadence will also directly affect customer acceptance.

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[230] *Id.* at 6-12.

Green Auto Loans

The Agencies cite that market innovation has led to the creation of "green auto loans" which "take fuel savings into account in the lending decision."[231] However, the available programs do not reference actually taking the future fuel savings into account when calculating the loan. Rather they offer this as an incentive to attract a particular type of loan applicant. For example, as one of the references provided in the Draft TAR states, while purchasers of certain efficient vehicles can benefit, "[t]he bank benefits as well because a review of its vehicle loan portfolio has shown that shoppers who purchase fuel-efficient autos are more likely to make their payments than consumers with other types of vehicles."[232] Ultimately, most "green auto loans" offer a 0.25% discount for financing certain hybrid or electric vehicles which is equal to or below a similar incentive most banks offer called "relationship discounts" which can offer loan interest rate discounts of 0.25-0.50% for initiating car loans where a customer also holds a checking or savings account.[233]

Critiques of Customer Acceptance Modeling Approach in OMEGA and the Volpe Model

Volpe Model Customer Acceptance

NHTSA addresses assumptions used within the Volpe model related to customer adoption of fuel economy technologies within Chapter 13 of the Draft TAR.[234] In general, the model predicts how manufacturers respond to increasing stringency of fuel economy targets by applying technology throughout the fleet. The Agency further states that the model uses fixed future sales volumes applied by the user as inputs and does not adjust sales as costs or attributes of vehicles generally change over the time period of the simulation.

NHTSA explains that the current Volpe model does not incorporate any type of "dynamic demand response" model to predict how sales of vehicles would change in response to attributes and costs. The Agency explains that Volpe has experimented with a variety of choice models, but that these prototype updates have not been incorporated into the current Draft TAR output. The Alliance requests that if further development of a dynamic demand response model is explored, or is intended to be used for the NPRM, that NHTSA release details of this model beforehand with sufficient time to stakeholders to review and provide comment to such a feature. As explained in Chapter 6 of the Draft TAR, EPA found significant inconsistency between

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[231] Id. at 6-19.
[232] Id. at 6-19, referencing footnote 55.
[233] Examples of these programs may be found at https://welcome.wf.com/greatrateevent/auto.html and https://www.soundcu.com/personal/auto-loans/green-auto-loans/.
[234] 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, (EPA-420-D-16-900, July 2016) at 13-1 et seq.

existing customer choice models and was not able to create a sufficiently robust model themselves to use in the Draft TAR. Coordinating efforts between the Agencies, and including feedback from industry will be critical should a choice model be introduced prior to any subsequent steps in the MTE process.

The Alliance generally agrees that if such a concept can be proven robust and reliable then eventually including customer choice models within the overall Volpe fleet model would be appropriate. This could help illustrate dynamic shifts in the marketplace as the simulated customers evolve their purchase patterns in response to increasing costs. NHTSA speculates throughout Chapter 13 that the price of vehicles may or may not reflect the costs of added technologies depending on how manufacturers price vehicles throughout their line-up.[235] The Agency seems to be indicating that certain segments of customers may not have to pay the full price for technologies if the manufacturers elect to shift pricing on other models such as through cross-subsidization, but no further details as to how such a scheme would work were provided.

The Draft TAR states that NHTSA has been evaluating multiple pricing models to use within the Volpe model, but that the current Draft TAR results use the traditional "pay as you go" approach which fully allocates each individual vehicle's technology cost only to that vehicle.[236] As stated previously with regards to the customer choice model, the Alliance requests early access to any pricing model which may be considered for use in later iterations of the Volpe model used to inform subsequent steps of the MTE.

While the Alliance cannot discuss pricing strategies directly and will leave this to the individual members, in general it is obvious that pricing of models within a fleet and even over the lifetime of each individual vehicle is highly variable and subject to individual considerations by each automaker. However, the output showing technology costs per vehicle individually provides a reasonable estimate of the impact of the standards on costs that a customer could face. There is some belief that premium segments could be priced higher in order to cover the cost of technologies applied to other, possibly lower cost, models where the cost could not be recovered by the manufacturer. However, not all manufacturers have a diverse line-up of vehicles, and some may not offer models with margins that could "absorb" losses on other vehicles. In addition, the Volpe model clearly shows significant technology costs being added to all vehicles across all pricing spectrums. For example, NHTSA claims that the full cost of compliance for passenger cars may approach $2,200 on average; the question of whether or not a low-volume high margin vehicle could cover its own cost, plus the cost of other lower cost vehicles, is speculative. Premium segments are competitive in unique ways; often customers do not value fuel economy in purchasing decisions but instead demand other features, such as high

[235] *Id.* at 13-8 et seq.
[236] As may be modified by the NHTSA analysis insomuch as it assumes certain manufacturers pay civil penalties in lieu of applying technology.

performance or advanced driver assist systems. It is not to be overlooked that customer demand for non-fuel-economy related technology has led to innovations throughout history by premium brands that have benefitted the entire industry, and the environment in other ways. An example of this is seen in 1991 when (long before regulations required it) Mercedes-Benz designed and built the first ever automotive chlorofluorocarbon (CFC)-free climate control system and eliminated CFCs from the entire manufacturing process. There are also real benefits to society in what these customers seek in terms of advancing safety technology (e.g. driver assistance systems), technology that reduces congestion (e.g. smart navigation), and technologies that reduce distracted driving (e.g. heads-up displays).

In conclusion, as NHTSA moves forward to consider adding customer choice algorithms or producer pricing strategies within future iterations of the Volpe model, the Alliance requests that significant effort is made as early as possible to include stakeholders such as automakers in the process. The magnitude of including either or both of these two macro issues, and how these could affect the consideration of future standards is deserving of a discussion much longer than a 60-day comment period allows.

The "effective cost" method used within the Volpe model attempts to estimate "what manufacturers believe consumers are willing to pay" for fuel economy technology.[237] As explained in the Draft TAR, the effective cost compares the cost of a technology minus the estimated three-year fuel savings (including discount rate) that a customer would expect to see.[238] The effective cost includes an additional calculation, once a manufacturer has achieved compliance, by examining the extent to which additional technology would be applied albeit using only one year of payback. The Alliance understands that NHTSA performed some sensitivity analysis with the Volpe model around this feature and the payback periods. The Alliance is uncertain if it is appropriate to apply two different payback periods for being under- and over-compliant with the standard. It is unclear how customers would know or why the would be concerned with the current compliance position of a manufacturer. It seems that a customer would apply a payback period that is specific to their valuation of fuel savings and not to the compliance position of a manufacturer. In essence, the Volpe model assumes full cost recovery of the technology and does not adjust sales for increases in price.

Economic Theory of Customer Acceptance

Customer acceptance issues center on the question of how customers value fuel economy improvements in new vehicles. The economic literature on this topic is known to be mixed, as the Draft TAR acknowledges.[239] This is not sufficient justification to abdicate any effort at

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[237] *Id.* at 13-10.
[238] *Id.* at 13-49.
[239] *Id.* at 10-19.

estimating the impact of higher standards on sales, and as manufacturers planning their business futures, automakers certainly do not have that option. Additionally, customer priorities and preferences, as well as affordability are key factors in customer acceptance.

The Draft TAR Fails to Estimate Sales Impacts

To estimate employment impacts, the Agencies must first determine the degree to which the standards will result in a change in vehicle sales. The Agencies do not make such an estimate in any of the chapters where such an analysis would be expected--neither in Chapter 6: Assessment of Customer Acceptance, nor Chapter 7: Employment Impacts, nor in Chapter 10: Economic and Other Key Inputs Used in the Agencies' Analyses, nor in Chapter 13: Analysis of Augural CAFE Standards.[240] Instead, the Agencies state that, because the standards in place since MY2012 are national in scope, and because of the inability to control for other macroeconomic conditions, there is no way to identify a baseline for measuring the impact on sales.[241]

Despite the many statements about being unable to estimate sales, throughout Chapter 4 of the Draft TAR future vehicles sales are projected.

In Chapter 4, EPA further explains how it adjusted the MY2014 baseline data for segmentation using IHS/Polk[242] and then scaled vehicle sales to AEO2015 levels.[243] But AEO2015 projects 17.2 million light-duty vehicle sales in MY2025, which is almost 800,000 more than what EPA shows as the AEO2015 reference case. EPA states that "[t]he unforced AEO2015 forecast alone does not have the necessary resolution, down to the vehicle segment level, for EPA to perform its analysis." [244] If EPA does not have the "necessary resolution" at the segment level, how did EPA then adjust the AEO reference case downward by 800,000 units? It is not clear if EPA removed or retained heavy-duty Class 2b and 3 vehicles from AEO's light-duty vehicle totals, and whether EPA's final projection includes medium-duty passenger vehicles (MDPVs) or not.

Regardless, the final EPA sales projections for MY2025 in Tables 4.4 and 4.5 (from the MY2014 baseline; with and without the standards) show no significant decrease in sales due to the increased cost of vehicle FE technologies that must be added to comply. Such a "no-decrease" sales projection as shown by Tables 4.4 and 4.5 is difficult to comprehend. Baseline projections of sales in 2025 absent the standards would be expected to be higher than projections of sales with the standards due to the lower price of vehicles. The Agencies have acknowledged a price elasticity for the demand of automobiles – that is, when price goes up, demand (sales) go down. In fact, as the Agencies reported when the standards were originally set, "There is a broad

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[240] *Id.* at 6-2, 6-17, 7-14, 13-94.
[241] *Id.* at 6-2.
[242] *Id.* at 4-12.
[243] *Id.* at 4-12.
[244] *Id.* at 4-12.

consensus in the economic literature that the price elasticity of demand for automobiles is approximately –1.0, meaning that every one percent increase in the price of the vehicle would reduce sales by one percent…"[245] Thus, the Agencies should at least have been able in the Draft TAR to attribute some reduction in vehicle sales to the anticipated increase in purchase price, using Agency projections of increased vehicle costs. It stands to reason that to arrive at a projection of no sales decrease, the Agencies did not make estimates or ignored the impact of, vehicle demand versus price elasticities, customer acceptance, gasoline prices, the economic situation in MY2025, and others. The actual assumptions used, or the values associated with such assumptions, are not clearlyshown in the Draft TAR. In the next steps of the MTE, the Agencies should provide, in detail, the assumptions relied upon in estimating sales in 2025.

The IHS/Polk spreadsheet data from the docket[246] (which assume the standards stay fixed from 2021 onwards) do project a decrease in sales due to the effect of higher gasoline prices, showing a difference of 1.2 million vehicle sales between the projections of EPA high gasoline prices and EPA low gasoline prices.[247] Since the IHS/Polk projections hold standards constant at 2021 levels, they do not provide information on what sales might be with the application of MY2025 standards.[248] The following graph (Figure E-9) plots these sales projections from the IHS/Polk spreadsheet:

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[245] "2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards." 77 Fed. Reg. 2012 FRM 62623 at 63102. (October 15, 2012).
[246] Docket ID EPA-HQ-OAR-2015-0827-0403.
[247] *Id.*
[248] *Id.*

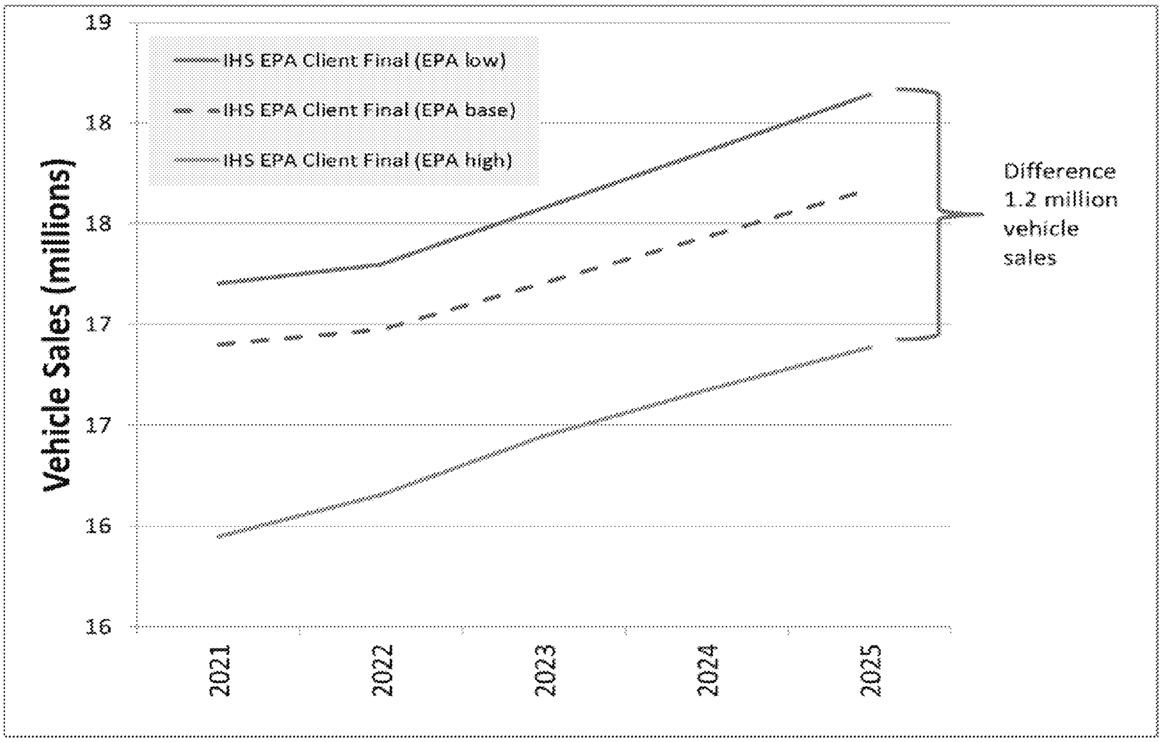

Figure E-9: Chapter 4 IHS/Polk Sales Projections from the Draft TAR[249]

Outside consultants have made baseline projections of sales in MY2025 absent the standards and these projections were available to the Agencies to use in the Draft TAR. For instance, the June 2011 version of the CAR 2025 Jobs report[250] makes a projection of a baseline sales level of 17.9 million vehicles sold in 2025 absent the 2009-2025 standards. A more recent September 2016 version of the CAR 2025 Jobs report[251] projects a baseline sales level of 18.64 million vehicles sold in MY2025 absent the MY2017-2025 standards. The IHS/Polk data projects sales of 16.9 million to 18.1 million in 2025, absent the standards.[252] We believe all of these "absent the standards" sales estimates to be in line, since the CAR's estimate of 18.64 million sales[253] assumes no additional government fuel economy mandates for the 2017-2025 period, not just the 2022-2025 period as the IHS/Polk estimates do.

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249 *Id.*

250 "The U.S. Automotive Market and Industry in 2025." Center for Automotive Research. June 2011. 40.

251 "The Potential Effects of the 2017-2025 EPA/NHTSA GHG/Fuel Economy Mandates on the U.S. Economy." Center for Automotive Research. September 2016. 36.

252 Docket ID EPA-HQ-OAR-2015-0827-0403.

253 "The Potential Effects of the 2017-2025 EPA/NHTSA GHG/Fuel Economy Mandates on the U.S. Economy." Center for Automotive Research. September 2016. 36.

Affordability

In December 2015, Kelly Blue Book reported the estimated average transaction price for light-duty vehicles in the United States had reached an all-time high of $34,428.[254] As vehicle prices have risen over time, and competing demands on incomes such as health care costs and other personal consumption expenditures have also expanded, customers are making various tradeoffs to maintain their transportation needs, but data suggest they are unwilling, or unable, to increase the share of their budgets allocated to transportation. The share of gross domestic product (GDP) spent on new vehicle purchases has held relatively flat, or even declined slightly outside of the financial crisis period. Customer spending on new vehicles, as a percentage of GDP, averaged 1.8% in the period from MY2000 to the present and appears to have plateaued at this level recently (Figure E-10) (slightly below its pre-crisis run rate).

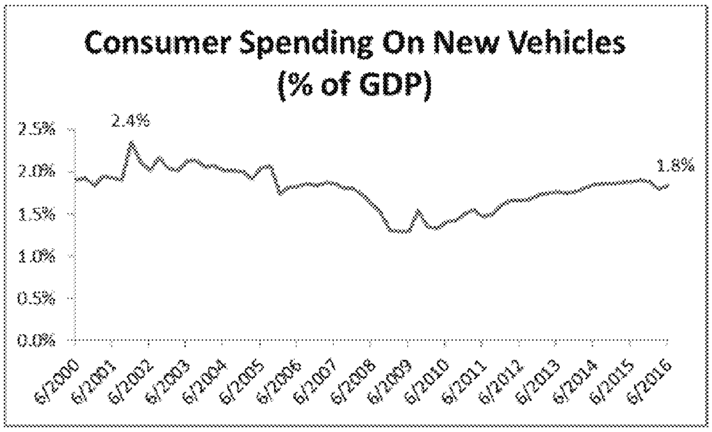

Figure E-10: Customer Spending On New Vehicles As Percentage of GDP, 2000-2016[255]

Over the past 15-20 years, as new car prices increased, interest rates dropped dramatically and remained low, as illustrated in Figure E-11, making it possible for customers to continue buying new light-duty vehicles. In essence, the increased vehicle cost was offset by the low cost of capital. In addition, average loan terms have lengthened significantly, approaching seven-year terms. Customers also seek affordability through the leasing mechanism to create an affordable monthly payment. Leasing across all new vehicle segments has increased from 27% in Q2 2015

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[254] Record New-Car Transaction Prices Reported In December 2015, According To Kelley Blue Book. Kelley Blue Book. Accessed September 26, 2016. http://mediaroom.kbb.com/record-new-car-transaction-prices-reported-december-2015

[255] New Motor Vehicle Expenditures data from Bureau of Economic Analysis, "Real PCE New Motor Vehicle Expenditures 2009 Chained Linked Dollars" (Table 2.4.6U. Personal Consumption Expenditures by Type of Product) and "Real PCE New Motor Vehicle Leasing Expenditures 2009 Chain Linked Dollars "(Table 2.4.6U. Personal Consumption Expenditures by Type of Product). GDP data from Bureau of Economic Analysis, Real GDP 2009 Chain Linked Dollars (Table 1.1.6). Bureau of Economic Analysis.

to 31% in second quarter 2016.[256] This has allowed customers to keep their monthly payments affordable during a period of stagnant household income.

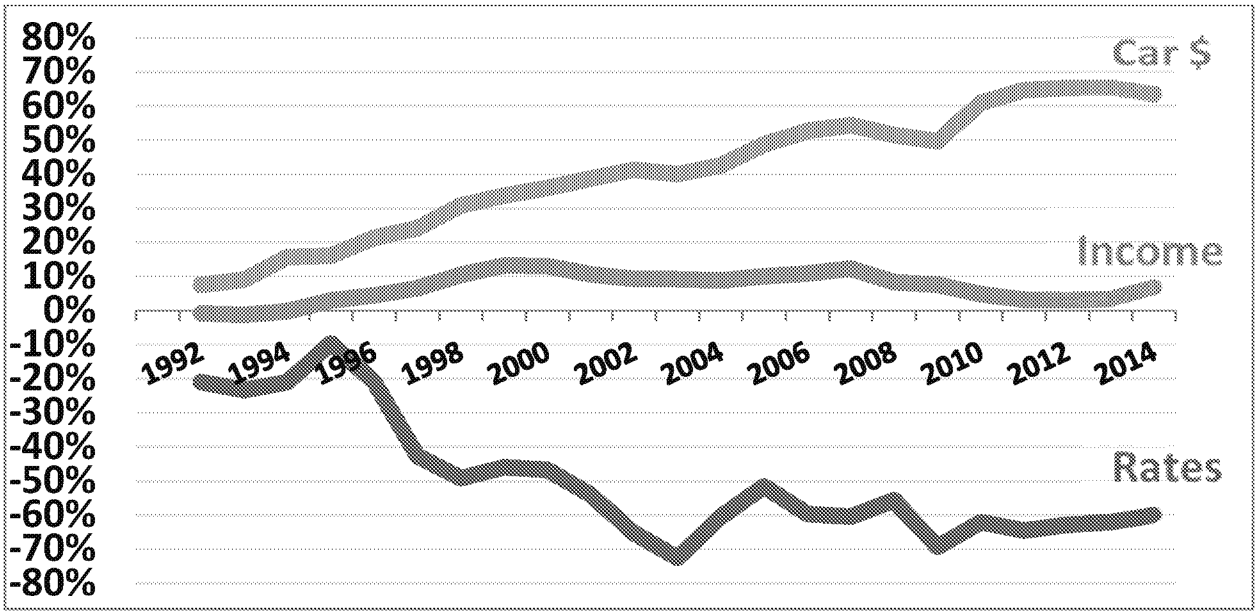

Figure E-11 Percent Change of Median Household Income, New Car Prices, And Interest Rates: 1991 Baseline

For the MTE, the Agencies (as well as Congress, state officials, and the general public) must evaluate how the slowdown in growth of disposable personal income,[257] combined with the Federal Reserve's recent decision to begin increasing interest rates (thereby increasing the cost of capital), will impact customers' ability to afford the increasingly expensive technologies needed to meet the future CAFE and GHG standards. This analysis must take into account that other regulations will simultaneously have an impact on vehicle production costs and achievable fuel economy. If customers have difficulty affording the cost of new technologies required for compliance, they may decide to hold onto their current vehicles longer or purchase from the used vehicle market. In either case, the "virtuous cycle" of fleet turnover with safer and more fuel-efficient vehicles is stalled and the standards do not achieve their anticipated benefits.

One accommodation customers can make in the face of rising vehicle transaction prices is indeed to hold their existing vehicles longer before replacement, which is increasingly possible with ongoing durability improvements. This translates into a lower percentage of households buying vehicles in any given year, which has been on a downward trend since 2000, and has only

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[256] "State of the Automotive Finance Market." Experian Automotive. 2016. 11. Accessed September 20, 2016. http://www.experian.com/assets/automotive/quarterly-webinars/2016-Q2-SAFM.pdf.
[257] United States Disposable Personal Income. Trading Economics. Accessed September 26, 2016. http://www.tradingeconomics.com/united-states/disposable-personal-income.

recently recovered to its pre-financial crisis rate (Figure E-12). Importantly for FE standards, this also means that new, more fuel efficient technologies, take ever longer to make it into the fleet. Additional pressure on new vehicle prices due to fuel economy standards, whether those features are valued by customers or not, will further extend vehicle holding periods and technology penetration rates.

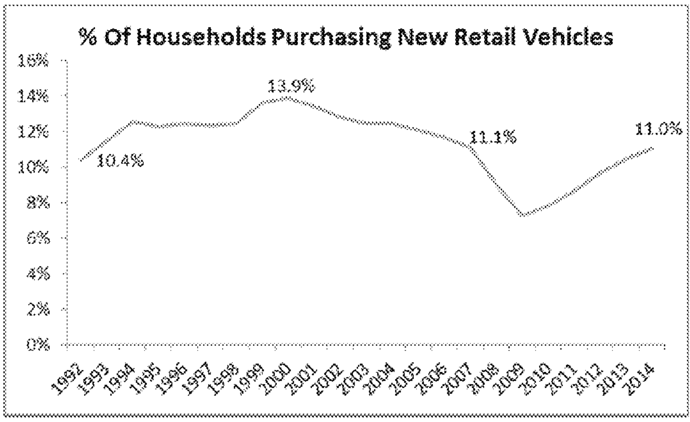

Figure E-12: Percentage of Households Purchasing New Retail Vehicles, 1992-2014[258]

These developments also push more households into the used vehicle market, leaving a gap between households able to afford a new vehicle versus the population as a whole. According to Steven Szakaly, Chief Economist of the National Automobile Dealers Association, the average new car buyer is 51.7 years old and earns about $80,000 per year, while the average age of the population is 36.8 years and the median income is roughly $50,000. As stated above, this implies that lower income households, with monthly expenditures most sensitive to changes in fuel prices, are also the least able to afford more fuel efficient vehicles.

Finally, in the years to come, the financing environment for new vehicles is unlikely to be as favorable as its current state. Interest rates remain near historic lows, but are on a path to increase according to published projections by the members of the rate-setting Federal Open Market Committee of the U.S. Federal Reserve.[259] Lending standards for new auto loans have begun to tighten (Figure E-13), as shown by the latest Senior Loan Officers Opinion Survey (SLOOS), and it is unclear how much further vehicle loan terms can be extended without putting too many customers into a prolonged negative equity position on their new vehicle loan. None of these factors appear to have been taken into account by the Draft TAR.

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[258] Vehicle sales data from FRED (Federal Reserve Economic Data), Federal Reserve Bank of St. Louis. Number of households from United States Census Bureau, Families and Living Arrangements, Table HH-1.

[259] "Economic projections of Federal Reserve Board members and Federal Reserve Bank presidents under their individual assessments of projected appropriate monetary policy, September 2016." Federal Open Market Committee. September 21, 2016. Accessed September 26, 2016. https://www.federalreserve.gov/monetarypolicy/files/fomcprojtabl20160921.pdf.

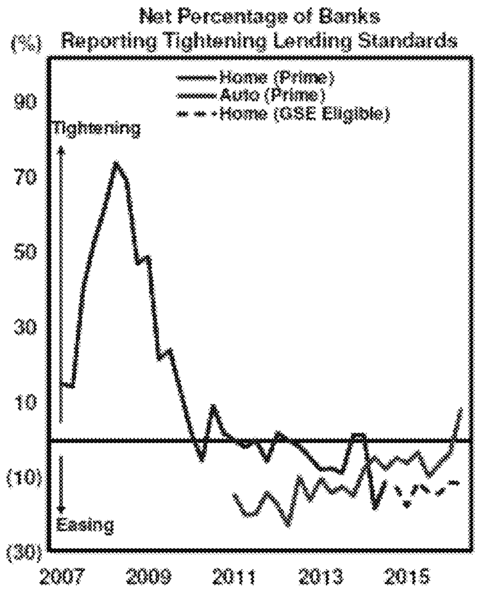

Figure E-13: Trends in Home and Automotive Lending Standards[260]

Customer Priorities and Preferences

A key component of the MTE should be an assessment of customer priorities and preferences when making a new vehicle purchase.

Strategic Vision conducts a comprehensive post-purchase survey of over 300,000 new car buyers each year, investigating the motivations driving customer choices. The 2015 NAS Report acknowledges that Strategic Vision provides “the most reliable information about consumer preferences.”[261]

Based on information gathered by Strategic Vision, Figure E-14 shows that interest in fuel efficiency must be considered contextually. while 32% of buyers assert “fuel economy is a leading consideration,” superior handling, ride comfort and a quiet interior are all attributes that respondents considered more important.

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[260] Federal Reserve Senior Loan Officer Opinion Survey

[261] “Cost, Effectiveness and Deployment of Fuel Economy Technologies for Light-Duty Vehicles.” National Academy of Sciences, National Research Council to the National Academies. 2015. 325.

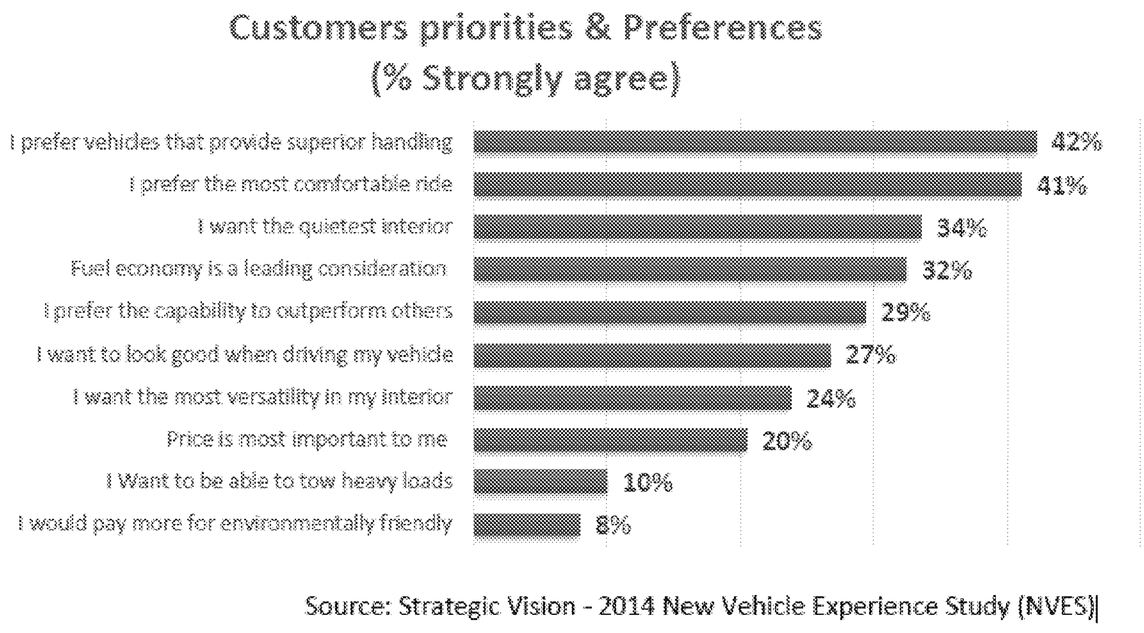

Figure E-14: Customer Priorities and Preferences

Customer Preferences and Willingness to Pay for Fuel Efficient Technologies

Customers choose vehicles to perform specific functions and select powertrains that have sufficient performance to meet those functions. Although customers prefer improved fuel economy when there are not tradeoffs against performance or price, the decision of which vehicle and powertrain to select becomes more complex when these tradeoffs must be considered. For example, if a powertrain option does not provide the towing and hauling capacity that a customer needs to accomplish the intended use of their vehicle, the customer may select a more capable powertrain. Similarly, customers may select a taller vehicle to comfortably accommodate their family and cargo. In both of these examples, the high fuel economy option within a particular vehicle model or class is not an option for the customer.

Furthermore, the Agencies modeled compliance strategies including downsized turbocharged engines, representing 33% of the EPA's modeled 2025MY fleet.[262] NHTSA modeled implementation of downsized turbocharged engines in 19% of passenger cars in MY2030 and 35% of trucks.[263] In the market, however, there are limits to the extent of downsizing and the potential performance loss that customers will accept. To entice customers to select a downsized turbocharged powertrain, fuel economy improvements alone are insufficient. Manufacturers

[262] 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, (EPA-420-D-16-900, July 2016) at 12-33, Table 12.41.
[263] *Id.* at 13-62, Table 13.30.

often must offer increased performance compared to baseline naturally-aspirated engines in the form of increased horsepower, torque, payload, and/or towing capability.

Four Wheel Drive / All Wheel Drive System Considerations

During the MTE, the Agencies were tasked with reviewing several independent relevant factors that impact the goals of this program. One area that has not been reviewed, but which touches on many of these factors is the fuel economy decrease associated with 4WD / AWD vehicles. This overlaps with many of the factors the Agencies deem relevant to the MTE, including impacts on fleet mix and safety; powertrain improvements for gasoline and diesel engines; and cost, availability, and customer acceptance of technologies to ensure compliance with the standards.

Impacts on Fleet Mix

Many areas of the country see yearly inclement weather and or are rural with a high percentage of dirt roads, which the Alliance believes can trigger 4WD / AWD preferences over 2WD. To determine whether or not registrations of 4WD / AWD vehicles trend towards states with either high snowfall or dirt roads (or both), the Alliance performed a comparison of available weather, road condition, and registration data. Registration data is based on new vehicle registrations in MY 2015 IHS Markit data for the U.S. Light Vehicle fleet (which includes passenger cars and light trucks/vans/SUVs in the GVW 1,2,3 weight class) and was separated by state for 2WD and 4WD / AWD.

The study took the top five most populous cities available for each state, and using snowfall data for these cities that originated from NOAA's National Climatic Data Center's "1981-2010 Climate Normals."[264] This study calculated a population-weighted snowfall average value for each state. The snow data used is based on a 30-year average and therefore does not include any effects of recent snow storms in certain areas that could have affected sales in certain states.

This study also examined the percentage of unpaved roads in each state. The data originated from the Federal Highway Administration which tracks the total miles of paved and unpaved roads for all major collectors, minor collectors, and local roads.[265] This study added all of the miles of paved and unpaved subtotals from each road category and divided by the total miles of road in each state to arrive at percentage of unpaved roads by state. Certain mountainous states are noted in the Figure E-15, which may also affect purchasing decisions, but no attempt was made to find any correlations. Furthermore, state activities such as rate of agriculture may also impact 4WD / AWD registrations (e.g. in Texas, as is shown in Figure E-15).

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[264] National Climatic Data Center. NOAA's 1981-2010 Climate Normals. National Oceanographic and Atmospheric Administration. Accessed September 26, 2016. https://snowfall.weatherdb.com/.
[265] U.S. Department of Transportation, Federal Highway Administration, Highway Statistics (Washington, DC: Annual issues), table HM-51. Accessed September 26, 2016. http://www.fhwa.dot.gov/policyinformation/statistics/2014/hm51.cfm.

Figure E-15 below shows the comparison of average snowfall, percentage of dirt road, and registrations of 2WD / 4WD / AWD vehicles. The Alliance believes that the aggregation of these data shows that for customers encountering either substantial snowfall each year, or a high percentage of dirt roads in their area, or both, there is correlation to registrations of 4WD / AWD vehicles. With few exceptions, states with high snowfall show a strong relationship to 4WD / AWD registrations. One exception below could be New York. However, using a population weighted snowfall in a highly urbanized area that has a significant public transportation and likely has a lower vehicle ownership rate, could outweigh the high snowfall effects of rural New York State customers.

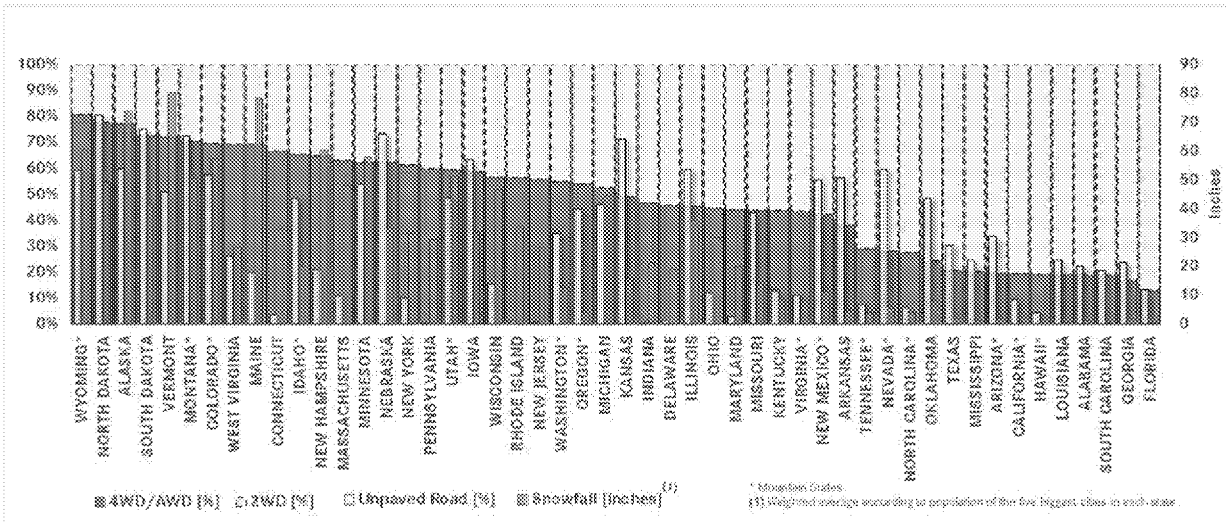

Figure E-15: 2WD / 4WD / AWD Sales by State v. Snowfall and Unpaved Road Conditions by State[266]

Impacts on Safety

- U.S. Department of Transportation (DOT) statistics show that 44% of all weather-related accidents occur due to winter conditions.[267]
- In addition to U.S. citizens living in areas with harsh winters, consideration must also be given to those living in rural areas where 31.5% of all VMT occurs and where the daily VMT is also 30% greater than in urban areas – these drivers are more likely to encounter dirt roads as over one-third of roads in America still remain unpaved.[268,269]

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[266] Analysis completed by the Alliance based on data from: 1) the U.S. Federal Highway Administration http://www.fhwa.dot.gov/policyinformation/statistics/2014/hm51.cfm, 2) https://snowfall.weatherdb.com/ 3) State volumes for drivetrain type provided by IHS Markit. IHS Markit data used with permission.
[267] "How Do Weather Events Impact Roads?" U.S. Deparment of Transportation. Accessed September 26, 2016. www.ops.fhwa.dot.gov/weather/q1_roadimpact.htm.
[268] U.S. Department of Transportation, Federal Highway Administration, Highway Statistics (Washington, DC: Annual issues), table HM-51. Accessed September 26, 2016. http://www.fhwa.dot.gov/policyinformation/statistics/2014/hm51.cfm.

- Footprint standards do not consider driving conditions customers encounter daily or frequently and their resulting choice in vehicle drivetrain selection.

Powertrain Improvement for Gasoline and Diesel Engines

Powertrain improvements can never bring parity between 2WD and 4WD / AWD systems in terms of efficiency. Therefore this functionality must be considered as a unique vehicle efficiency constraint and not continually viewed as a penalty for which customers must pay.

Cost, availability, and customer acceptance of technologies to ensure compliance with the standards

- Customers must value the utility and safety benefits of 4WD / AWD enough to pay the added premium, which can be well upwards of $1,500, and forgo the loss of fuel efficiency as a result because 4WD / AWD systems add complexity and weight to the vehicle.
- In the absence of a CO_2 offset for 4WD / AWD systems, customers could be forced to purchase additional technologies that offset some or all of the fuel economy difference between a two-wheel drive and four-wheel drive version of a vehicle. The price increases associated with the added technology may result in customers being priced out of purchasing the added safety associated with 4WD / AWD.

A precedent to Agency recognition for the need to distinguish the utility of 4WD / AWD systems and avoid penalizing customers purchasing this feature can be found in the Agencies' heavy-duty GHG program. In that rule, an adjustment for 4WD vehicles was included. This was done to account for the fact that these systems are critical to enabling off-road heavy-duty work applications and because they add significant weight to the vehicles. It does not make sense for a similar factor to be excluded from the light-duty program, where purchase of this feature can be clearly seen to be unrelated to increased performance. Rather, sales data shows the 4WD / AWD system to be an essential feature in terms of both added safety and utility to customers in areas of the country with harsh winters. The cost and complexity of a 4WD / AWD system is too great for automakers to install as a way to gain relief from the standards. Removing the penalty on 4WD / AWD vehicles will ensure the Agencies honor their intent of preserving consumer choice "—that is, the standards should not affect consumers' opportunity to purchase the size of vehicle with the performance, utility and safety features that meets their needs."[270]

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[269] "How Do Weather Events Impact Roads?" U.S. Department of Transportation. Accessed September 26, 2016. www.ops.fhwa.dot.gov/weather/q1_roadimpact.htm..

[270] "EPA and NHTSA Set Standards to Reduce Greenhouse Gases and Improve Fuel Economy for Model Years 2017-2025 Cars and Light Trucks." U.S. Environmental Protection Agency. EPA-420-F-12-051. August 2012. 2. Accessed September 26, 2016. https://www3.epa.gov/otaq/climate/documents/420f12051.pdf.

Other Relevant Factors

Environment Canada has historically aligned with the U.S. federal GHG emissions program. This can, however, lead to problems due to differing market conditions where demands in Canada as compared to the U.S. can result in unintended consequences for Canadian customers. Environment Canada has worked with the Agencies to study the emissions implications of improvements in AWD systems, presumably because the rate of adoption of AWD / 4WD vehicles is so much greater due to Canada's colder climate, winter driving conditions, and terrain. Environment Canada had considered greater flexibility for AWD / 4WD vehicles in the past to align with Canadian customers' needs. However, the desire for harmonization with the U.S. program was more important at that time. More time is needed to review and discuss the results of this AWD / 4WD study and its conclusions on what is and is not possible for AWD / 4WD system efficiency improvements.

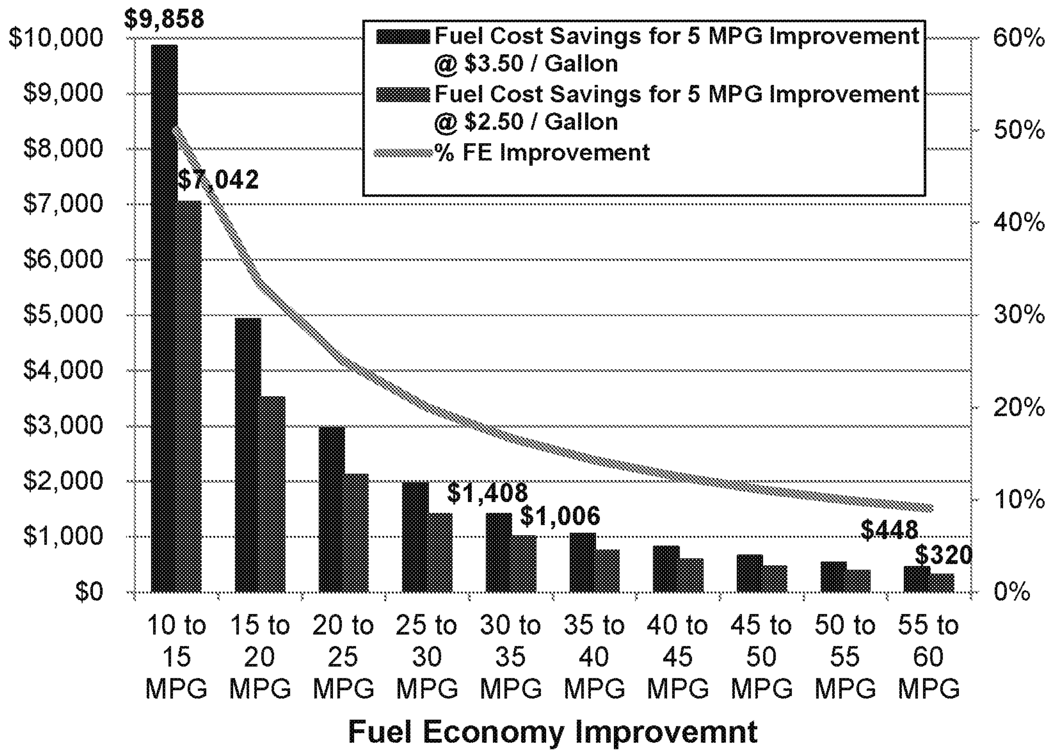
Additional Functionality

An additional challenge to customer acceptance of fuel efficiency technology is the growing popularity of advanced technology such as connectivity, infotainment, and driver assistance features which are undergoing a period of rapid change and innovation across the industry. New features are being offered, such as embedded modems, allowing control of certain vehicle features by smartphone app, while advanced driver assistance systems such as lane-keeping systems and adaptive cruise control are expanding beyond the premium segment. These features are growing in availability and demand and will compete with fuel efficiency technology for incremental vehicle spending by customers.

Not all advanced technologies such as driver assistance or coaching come absent additional fuel efficiency benefits as advancements have enabled most automakers to include significant driver feedback systems which monitor fuel efficiency to encourage the driver to ultimately use less fuel. Unfortunately, in the 2012 FRM discussion surrounding this type of technology, the Agencies seemed unwilling to consider these technologies for off-cycle credits. The unintended consequence of this is that automakers may not be able to continue to pursue technologies that do not provide certainty in supporting vehicle compliance.

Fuel Economy Savings Are Reduced for Highly Efficient Vehicles

Customers that choose a more efficient vehicle will see the cost to benefit ratio decrease as fuel economy increases. This effect is more pronounced as fuel costs decrease. Customer willingness to pay for improved fuel economy diminishes as fuel economy improves and fuel savings decrease (Figure E-16).



Note: assumes 6.5 years of ownership and 13,000 miles driven per year.

Figure E-16:Fuel Savings with Better Fuel Economy

Adoption of Advanced Fuel Efficiency Technology

Adoption by customers of fuel economy technology under the MY2012-2016 GHG and FE standards has been slower than anticipated for many technologies, particularly those that are viewed by the customer as new technologies, DCTs, strong hybrids, and mild hybrids. These technologies can have a noticeable impact on vehicle aspects such as acceleration, braking, and shifting.

DCTs shift more suddenly than traditional planetary gear-based automatic transmissions with torque converters, which is particularly noticeable when accelerating from a stop and has led to drivability concerns from customers. Although DCTs have had wider customer adoption in other markets with higher usage of manual transmissions, U.S. customers are accustomed to the smooth, gradual shift enabled by a torque converter.

Novation Analytics conducted a study of technology deployment for MY2012-2015 vehicles including more than 1,400 vehicle models and subconfigurations for the MY2015 based on vehicle data submitted by manufacturers to EPA.[271] Actual implementation for MY2012-2015 vehicles was compared to the Volpe model projections from the 2010 FRM.

In the Volpe forecast from the 2010 FRM, DCTs were expected to be implemented in 69% of light-duty vehicles by MY2015, increasing to 76% of the fleet in MY2016 .[272] According to the Novation Analytics study, actual fleet implementation in MY2015 was only 2.8%, a decline from MY2012.[273] In the Draft TAR, NHTSA modeled only 7% share for DCT in MY2021 for passenger cars and 3% for light trucks, while transmissions with seven or more speeds and CVTs were modeled at 51% share for passenger cars and 64% for light trucks.[274] Similarly, EPA expanded the definition of advanced transmissions to allow greater penetration of seven or greater speed transmissions and CVTs.

The experience with DCTs, and the Agencies' subsequent adjustment in the Draft TAR to assume significant penetration of seven or more speed planetary gear-based transmissions and CVT, demonstrates that customers may not accept the assumed technologies that were modeled by the Agencies to provide the most cost-effective fuel efficient improvements, particularly when there are noticeable impacts to drivability.

Similarly, according to the Volpe forecast from the 2012 FRM, mild hybrids were expected to represent 24% of light-duty vehicles in MY2015, but the actual share did not exceed 0.1% from MY2012-2015 according to the Novation Analytics Baseline Study.[275] Customers did not broadly adopt market offerings that were available during this timeframe. The Agencies' updated analysis in the Draft TAR again projects significant expansion of mild hybrids, reaching 24% share of MY2030 passenger cars according to NHTSA[276] and 10% of MY2025 cars according to EPA.[277] EPA modeled 27% of MY2025 trucks as mild hybrids, leading to a total fleet penetration of 18%.[278] The past experience with mild hybrids compared to earlier projections demonstrates that the Draft TAR forecasts may be difficult to achieve as customers are hesitant to embrace new and unfamiliar powertrains.

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[271] "MY 2015 Baseline Study," Novation Analytics. September 2016. 8. Attached as Attachment 10.
[272] CAFE Compliance and Effects Modeling System: The Volpe Model. Version 2010 Final Rule for Model Years 2012-2016 Passenger Cars and Light Trucks. National Highway Traffic and Safety Administration. Accessed September 26, 2016. http://www.nhtsa.gov/Laws+&+Regulations/CAFE+-+Fuel+Economy/cafe-volpe-model.
[273] "MY 2015 Baseline Study," Novation Analytics. September 2016. 40.
[274] 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, (EPA-420-D-16-900, July 2016) at 13-63 and 13-69, Figures 13.31 and 13.35.
[275] "MY 2015 Baseline Study," Novation Analytics. September 2016. 41.
[276] 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, (EPA-420-D-16-900, July 2016) at 13-64, Figure 13.32.
[277] *Id.* at 12-33, Table 12.41.
[278] *Id.* at 12-33, Table 12.41.

Hybrid and Plug-In Electric Vehicles

Limited Growth of Electrified Vehicle Sales

Electric vehicle adoption is an important issue related to compliance with the MY2022-2025 GHG and FE standards. As is described in these comments, automakers are expected to rely on a greater share of hybrid and plug-in electric vehicles to comply with the standards than is projected by the Agencies in the Draft TAR. However, the current electric vehicle (EV) buying audience is limited and lacks natural demand. As shown in Figure E-17, PHEV and BEV sales remain under 1% of industry sales, while HEV sales have stagnated around 2% of the market despite being a technology available for almost two decades. Customers have continued to prefer traditional gasoline-powered vehicles. This may be due to perceived concerns related to adapting to new technologies, availability of charging infrastructure, and increased costs for vehicle purchase and battery replacement. We find that with the combined bundle of attributes offered by vehicles available today, gasoline vehicles continue to be most attractive to customers and there is a significantly lower willingness to trade-off to EV technology.

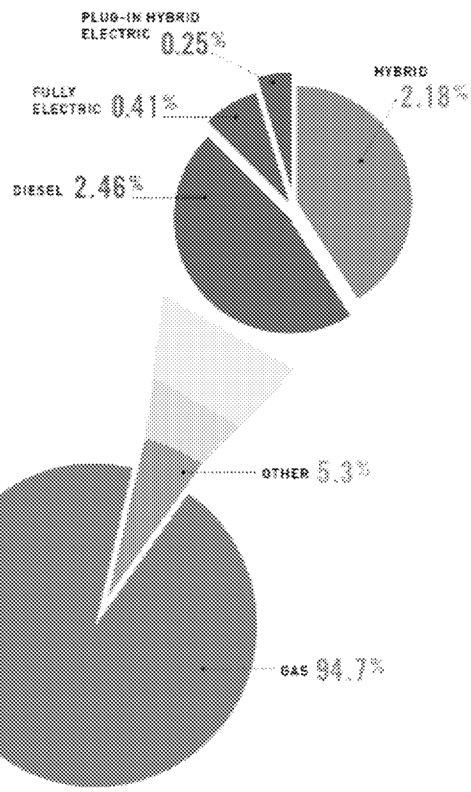

Figure E-17: 2015 Market Share by Powertrain Type[279]

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[279] WardsAuto Fuel Economy Index 2015 State of the Industry.

The Alliance respectfully disagrees with the Agencies' sensitivity analyses conclusions that fuel prices do not impact technology penetrations nor affect fleet electrification.[280] In the Alliance's view, recent experience demonstrates that gasoline price is a significant influencer on EV sales, which are defined here to include battery electric, hybrid electric, fuel cell, and plug-in hybrid electric vehicles. Since 2013, EV industry share in the US has declined from 4% to 2.7% by the end of 2015, according to IHS Markit. Figure E-18 presents the industry share of EV registrations compared to gas prices. The Alliance believes this data demonstrates that the shift in EV registrations mirrored the trend in gas prices over this timeframe, as car buyers placed a lower priority on fuel savings. As the Agencies have recognized the AEO2015 fuel prices, they have noted that the fuel price reference case indicates that prices will remain under $3/gallon through 2025, which the Alliance believes will continue to impact EV sales.

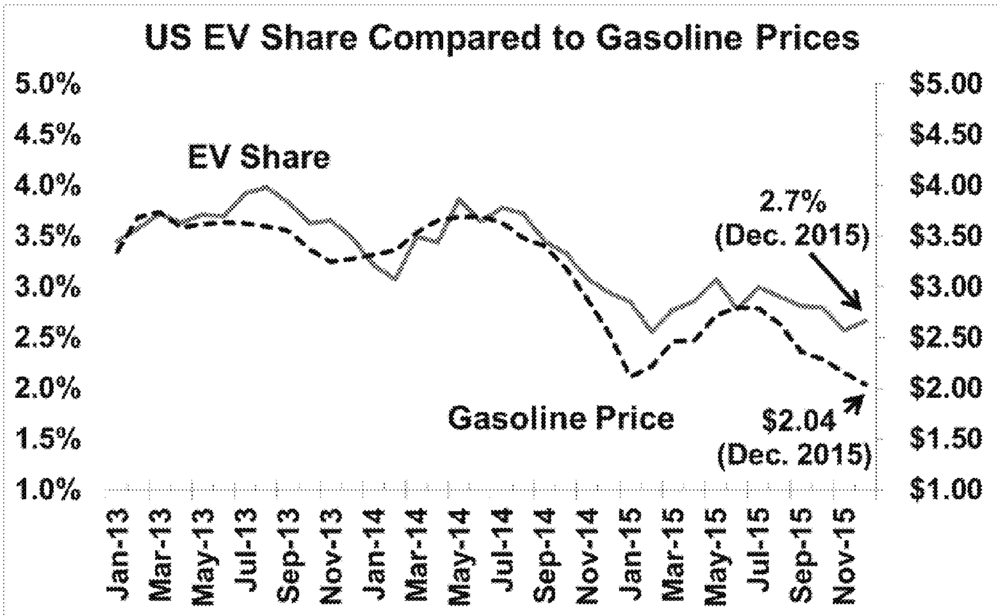

Figure E-18: EV share based on IHS Markit total U.S. new light vehicle registrations (cars and trucks) for each of the years shown for BEVs, PHEVs, Fuel Cell Vehicles and HEVs. Gasoline prices sourced from U.S. EIA.[281]

Decaying residual values further erode the value proposition to EV intenders. Low gas prices have exacerbated this trend as overall demand for EVs has decreased. Kelley Blue Book projected the 36-month residual value of hybrid and plug-in electric vehicles sold in the first two months of 2016 as 29.5%, a decline of 4.1 percentage points from the prior year.[282] If other

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[280] 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, (EPA-420-D-16-900, July 2016) at 12-40.

[281] IHS Markit and U.S. EIA - Used with permission of IHS Markit

[282] *Automotive News*, Sawyers, Arlena (2016). "Cheap gas hits hybrid, EV residuals." Accessed September 15, 2016. http://www.autonews.com/article/20160130/OEM05/302019987/cheap-gas-hits-hybrid-ev-residuals.

factors were responsible for the decline in non-premium EV residual values, this trend would be expected to be apparent in the residual values of all new vehicles. However, according to the National Automobile Dealers Association (NADA), hybrid and plug-in EVs depreciated at 25-35% in 2015, compared to an average of 16.5% for non-EV cars and trucks.[283] This demonstrates that non-premium EVs were uniquely affected by the decline in gas prices and changing customer preferences. Figure E-19 shows the dramatic difference in depreciation between an electric Nissan Leaf and its comparable counterpart gasoline vehicle, the Nissan Versa.

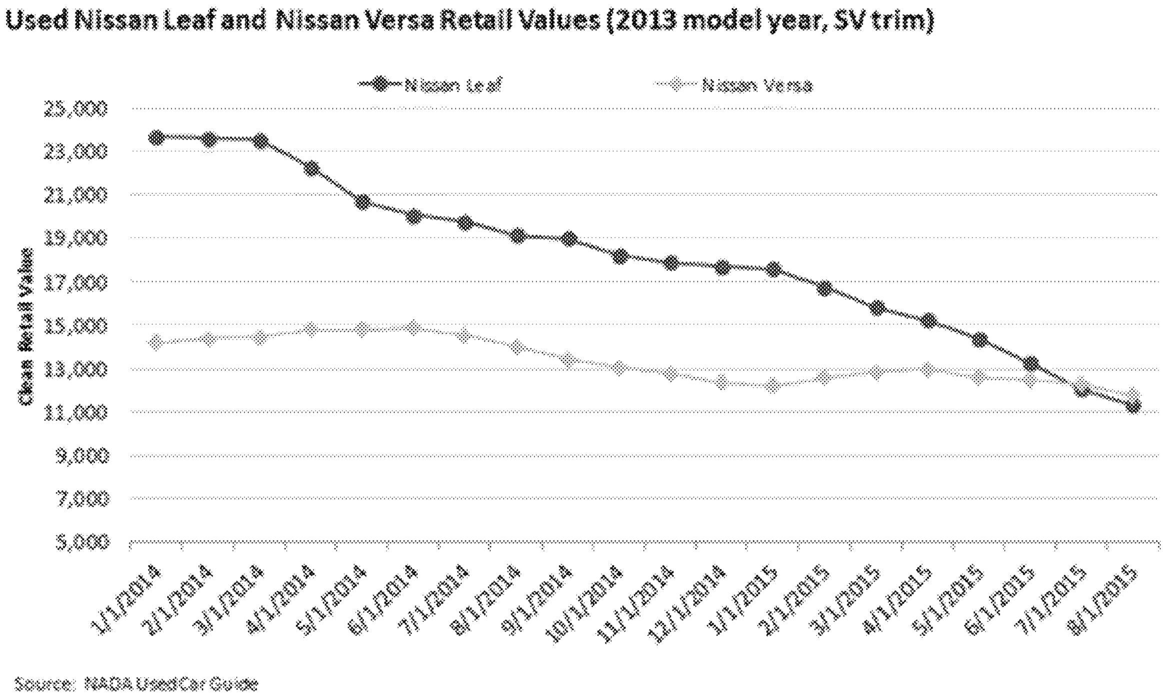

Figure E-19: Used Nissan Leaf and Nissan Versa Retail Values (MY2013, SV Trim)[284]

Reduced residual value compared to gasoline models is another factor limiting customer demand for non-premium EVs.

The low gas price environment has reduced expected cost savings and payback from driving a hybrid or plug-in electric vehicle, while residual values for these vehicles have also decreased in tandem with gas prices. The combined effect of these factors significantly reduces the value proposition for electric vehicles, and EV sales have declined as a result. Low fuel prices and the resultant shift in customer demand materially affect the ability of manufacturers to comply with

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[283] *Id.*
[284] Electric Vehicle News: EV Roadmap 8 Conference. National Automobile Dealers Association. Accessed September 26, 2016. http://www.nada.com/b2b/NADAOutlook/UsedCarTruckBlog/tabid/96/entryid/754/electric-vehicle-news-ev-roadmap-8-conference.aspx.

both the GHG and the ZEV regulations–reducing not only future sales, but also sales over the last few years. But for the low fuel prices and lackluster customer demand, automakers would have accrued GHG and ZEV credits for use in future years when requirements dramatically increase. The Agencies should study the impact of low gasoline prices on EV residual values, the impact of residual values on customer acceptance of EVs (particularly for non-premium EVs that represent a broader portion of the market), and the impact these have on automakers' ability to comply with the regulations.

Manufacturer Efforts to Promote Electrification

The limited market for EV sales is not for lack of manufacturer research and development, investment, advertising, or customer incentives. As an example, General Motors released an advertisement for the redesigned Chevrolet Volt six months before the car was set to release. Other automakers such as BMW Group, Ford Motor Company, and Toyota have featured their EVs in clever prime-time (including Super Bowl) television advertisements.[285,286] Manufacturers have invested significant resources to develop and sell these vehicles; growing the market can mean increasing sales and reducing incentives which is the desired outcome. Manufacturers have reduced the suggested retail prices of EV offerings and increased incentives in response to the risks posed by customer adoption trends. Increased manufacturer incentives have yet to offset the share decline and motivate non-premium EV customers, however. As shown in Figure E-20, although transaction prices in the overall industry are trending upward, mainstream (i.e. non-premium) plug-in EV prices declined 9% from January 2015 to August 2016 as manufacturers increased incentive spending on non-premium EVs.

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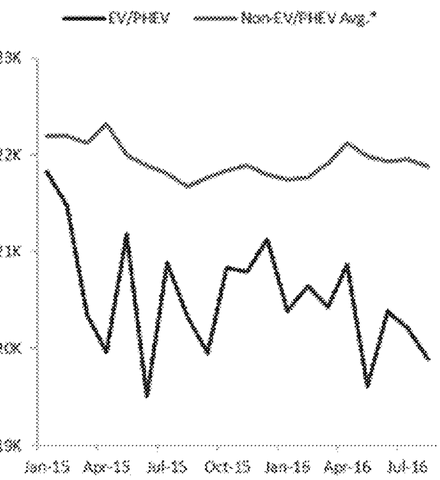
[285] *See* 6 Electric Vehicle Ads That Make a Brilliant Case for EVs. Autos Cheat Sheet. Accessed September 26, 2016. http://www.cheatsheet.com/automobiles/6-electric-vehicle-ads-that-make-a-brilliant-case-for-evs.html/?a=viewall.
[286] 2016 Chevrolet Volt TV Ad Released 6 Months Before Car. Green Car Reports. Accessed September 26, 2016. http://www.greencarreports.com/news/1096475_2016-chevrolet-volt-tv-ad-released-6-months-before-car.



*Comparison includes only those segments where BEV/PHEV segments exist

Figure E-20: Average Customer-Facing Transaction Prices for Mainstream Plug-In Electric Vehicles and Other Vehicles, 2015-16[287]

Automakers offer significantly higher incentives on plug-in vehicles compared to non-EVs in the same segments, and incentive spending for plug-in vehicles has increased since 2015 (Figure E-21). Automaker incentives for mainstream plug-in EVs average more than $8,000. Combined with the federal tax credit for EV purchases, total incentives for mainstream plug-ins average more than $12,000. Increased OEM incentive spending has contributed to declining average customer-facing transaction prices in the segment, as is described above.

[287] J.D. Power & Associates - Power Information Network. Used with permission of J.D. Power.

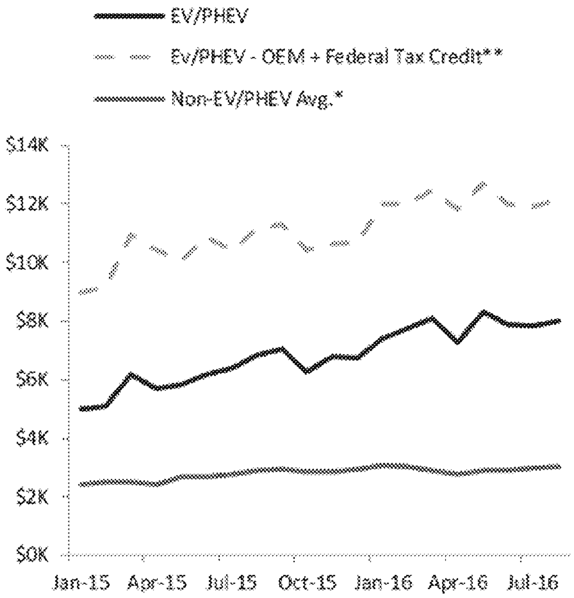


Figure E-21: Average Incentive Spending and Federal Tax Credit Benefits For Mainstream Plug-In Electric Vehicles and Non-EVs, 2015-2016[288]

The 2016 Lincoln MKZ offers a relevant example for customer acceptance of hybrid electric vehicles. The 2016 MKZ was offered with a variety of powertrains including a 2.0L Hybrid, 2.0L EcoBoost and 3.7L V6. Lincoln priced the 2.0L Hybrid and 2.0L EcoBoost variants at identical retail pricing, providing the opportunity for customers to choose a hybrid without incurring additional cost, even at the base price. If customers are motivated by fuel savings, most would be expected to choose the hybrid to reduce fuel costs without increasing their upfront cost. Figure E-22 shows that only 30% of MKZ customers selected the hybrid, while 70% chose a gasoline powertrain. Customers did not elect to purchase the hybrid powertrain, possibly due to the slightly decreased performance found with the hybrid powertrain, uncertainty about new technology, or preference for the familiar driving experience of a traditional powertrain. The Lincoln MKZ sales results represent a nationwide experiment in customer preference for hybrid electric vehicles compared to gasoline powertrains on the same vehicle model at the same price. The results, with hybrid share at less than half the share of gasoline, demonstrate that manufacturers face challenges in marketing EVs even when offering significant incentives.

[288] J.D. Power & Associates - Power Information Network. Used with permission of J.D. Power.

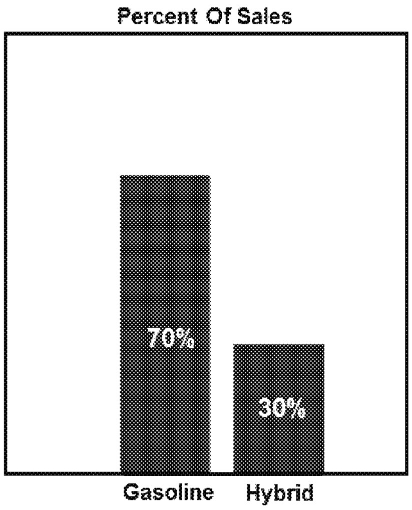


Figure E-22: 2016 Lincoln MKZ Gasoline and Hybrid Customer Take Rates[289]

For the majority of PHEV, HEV, BEV, and fuel cell vehicle offerings in 2015, affordable pricing has not stimulated shopping. Of the EV Market, 81% is represented by non-luxury vehicles, according to IHS Markit.[290] Figure E-23 outlines the segmentation of the full EV market. More than 50% of the EV market is non-luxury compact cars that, after incentives, are generally near the entry-level price points in the new vehicle market.[291] Low familiarity with new technology, concerns on range, and lifestyle compromises (size, payload and towing capability, etc.) appear to continue to obstruct customer willingness to embrace technology for the price.

[289] Courtesy of Ford Motor Company.
[290] IHS Markit - Used with permission of IHS Markit
[291] *Id.*

Segment Share of EV Registrations

Non-Luxury Segmentation: 15CY		Luxury Segmentation: 15CY	
COMPACT CAR	51.6%	SUB COMPACT CAR	5.7%
MID SIZE CAR	21.7%	FULL SIZE CAR	5.4%
SUB COMPACT CAR	2.9%	MID SIZE CAR	2.4%
FULL SIZE CAR	2.5%	COMPACT CAR	2.2%
COMPACT CUV	1.6%	MID SIZE CUV	2.1%
MID SIZE CUV	0.8%	COMPACT CUV	0.5%
COMMERCIAL TRUCK	0.1%	SPORT	0.4%
MID SIZE SUV	0.1%	EXOTIC	0.1%
FULL SIZE SUV	0.0%	FULL SIZE SUV	0.0%
FULL SIZE 1/2 TON PICKUP	0.0%	**Luxury Total**	**18.8%**
COMPACT VAN	0.0%		
Non-Luxury Total	**81.2%**		

Segment share of EV registrations based on on IHS Markit total U.S. new light vehicle registrations (cars and trucks) for 2015 for BEVs, PHEVs, Fuel Cell Vehicles and HEVs.

Figure E-23: Industry Electric Vehicle Segmentation, 2015 Calendar Year (Luxury/Non-Luxury)[292]

To date, many EVs considered as "luxury" have prioritized high performance, such as the Tesla Model S which can reach 0-60mph in as little as 2.5 seconds.[293] The luxury EV segment (representing 19% share of EV registrations in 2015[294]) has seen recent growth. Where luxury or high performance EVs can offer radically new technology or record setting performance, certain customers can be drawn to this segment and are willing to pay a premium to be part of a technological advance. A study from King Abdullah Petroleum Studies and Research Center (KAPSARC) found that affluent BEV adopters value powertrain performance, availability of rear-wheel drive, seating, and cargo capacity more than other BEV buyers.[295] As demonstrated by the KAPSARC results, luxury EV segment customers desire performance more than non-luxury EV buyers and are willing and able to spend on EV technology.

Tax Incentives for Electric Vehicles

Plug-in electric vehicle sales have been supported by federal tax incentives whose amounts are determined by battery capacity, along with additional incentives and rebates in some states and local districts. The incentives generally support both vehicle purchases and leases and are combined with manufacturer rebates and incentives. Federal incentives are scheduled to phase out after a manufacturer sells 200,000 qualifying vehicles.

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[292] *Id.*
[293] Tesla Model S. Tesla. Accessed September 26, 2016. https://www.tesla.com/models.
[294] IHS Markit. Used with permission of IHS Markit
[295] Dua, et al. "Understanding Adoption of Energy-Efficient Technologies: A Case Study of BEV Adoption in the U.S." 2016. KAPSARC. 35.

Stimulating customers towards lower priced, non-premium EV vehicles with government subsidies appears logical, however the nuances of present incentive structures favor vehicles with larger battery packs which likewise mean higher prices. Mass adoption is not promoted because customer preferences are not aligned. Furthermore, the federal incentives are volume-limited and do not support long-term compliance with the standards. Government incentives have supported deployment of electric vehicles to early adopters to achieve the limited market share seen to date, but are not expected to be available to support mass-market growth.

Third-Party Reviews of Electrified Vehicles

Third-party automotive website reviews attempt to make the car buying process simple through fair product assessment and education for customers prior to their purchase decision. Simple site navigation and increased use of the visual web are strengths, however in assessing the usefulness of these sites during the shopping process, J.D. Power identifies a gap in satisfaction between third-parties and the manufacturers.[296] Key findings state that an expert review must cover the basics with priority on safety, performance, and functionality. While using J.D. Power's criteria for automotive third-party sites pertaining to the basics of EVs, safety and functionality are not primary variables.

As noted in Kelley Blue Book's Best Green Cars,[297] the basis of their ranking was most efficient vehicles across all price ranges and powertrain variabilities. The lack of the total ownership and value for the money propositions kept "green" vehicle intenders misinformed of safety and functionality.

Autotrader's "8 Least Expensive Electric Vehicles" report from January 2015[298] lists the cheapest BEV/PHEV and range, but did not educate customers on safety features, powertrain performance, functionality, or reality of real-world acceptance.

Overall, for self-motivated EV buyers, the most important research content can be found on the manufacturers' sites. Auto reviews simply provide validation of products dependent on their criteria as Best or Top Picks without applying the non-premium customer product attribute priorities such as value for the money.

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[296] "2016 Third-Party Automotive Website Evaluation Study: Visual Web, Minimalist Navigation Tools Drive Increases in Shopper Satisfaction." J.D. Power. March 24, 2016. Accessed August 31, 2016. http://www.jdpower.com/cars/articles/jd-power-studies/2016-third-party-automotive-website-evaluation-study-visual-web.

[297] "10 Best Green Cars Of 2015 Named By Kelley Blue Book," Kelley Blue Blook. April 16, 2015. Accessed August 31, 2016. http://mediaroom.kbb.com/2015-04-16-10-Best-Green-Cars-Of-2015-Named-By-Kelley-Blue-Book.

[298] "8 Least Expensive Electric Vehicles," *AutoTrader*. January 2015. Accessed August 31, 2016. http://www.autotrader.com/best-cars/8-least-expensive-electric-vehicles-234077.

Expanded Choice and Competition in EV Market

The EV marketplace (hybrid, plug-in hybrid, and battery electric vehicles) is rapidly changing and growing with 46 models of hybrids, 18 battery electric models, and 12 plug-in hybrids offered in MY2015.[299]

Moreover, PEVs are offered in a variety of vehicle categories as shown in Table E-1 below.

EPA Vehicle Category	Number of Models
Mini-compact Car	1
Two-Seater	1
Subcompact Car	7
Compact Car	5
Midsize Car	6
Large Car	3
Small Station Wagon	1
Small SUV	1
Standard SUV AWD	5
Mini-Van (end of CY2016)	1

Table E-1: EPA Categories for Plug-In Electric Vehicles

The growth of EV product entries will address the issue of product variety and choice to the mainstream buying audience. However, the relatively stagnant sales rates, combined with new entries, will lead to fierce competition within the already small marketplace.

In some states, the cost of leasing some EVs is actually negative. For example, as shown in Figure E-24 below, a recent review of on-line advertised leasing rates combined with federal, state and local incentives show that low-income customers in the San Juaquin Valley can make money if they lease a Chevrolet Spark, Volkswagen e-Golf, Fiat 500e, Smart fortwo, Kia Soul EV, or Nissan LEAF.

[299] www.FuelEconomy.gov

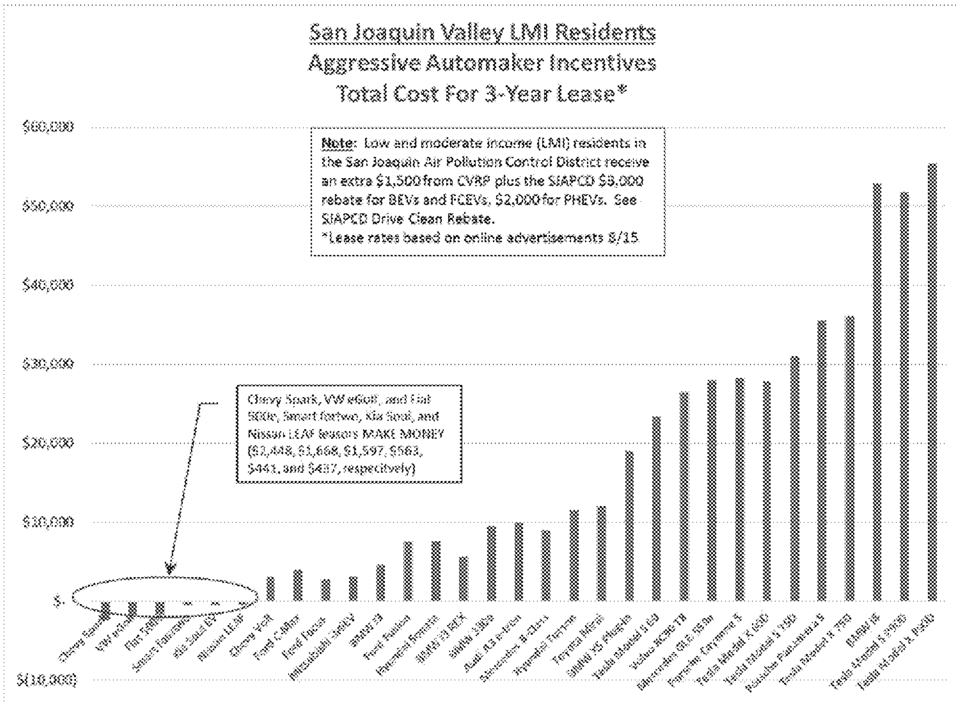

Figure E-24: Total Cost of 3-Year Lease for Low Income San Joaquin Valley Residents300

The extraordinary OEM incentives and extended financing solutions used to persuade customers with a manageable average transaction price/monthly carry-cost will be further stressed by increasing technology costs particularly on the non-premium EV vehicles which represent a majority of the marketplace.

Insurance Rates

In June of 2014, NHTSA published a comparison of differences in insurance costs for vehicles on the basis of damage susceptibility; dealerships were required to place copies of this guide in showrooms for prospective vehicle purchasers.[301] The report presents vehicles' collision loss data compiled by the Highway Loss Data Institute for MY2011-2013.[302] The report presents this loss experience in relative terms, with "100" representing the average damage payment for all passenger vehicles, where a rating over 100 is worse than average, while a score of less than 100 is better than average. The guide presents data on hundreds of vehicles and includes 22 HEV, PHEV, and BEV models. For this sample of vehicles with electrification, only two had scores of

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[300] Based on research of internet advertised leased deals as of August 15, 2016. Calculated total cost equals monthly lease rate multiplied by lease term, plus down payment, less California Clean Vehicle Rebate amount, low income California Clean Vehicle Rebate, and San Joaquin Valley Drive Clean Rebate.
[301] "Comparison of Differences in Insurance Costs for Passenger Cars, Station Wagons, Passenger Vans, Pickups, and Utility Vehicles on the Basis of Damage Susceptibility." National Highway Traffic Safety Administration. June 2014. Accessed September 26, 2016. http://www.nhtsa.gov/theft.
[302] *Id.*

less than 100, and in total ranged from 91-236 with the average of the 22 vehicles at 127. This indicates that it is not unthinkable that, by adding additional technologies, the price to repair vehicles will increase. The Agencies should study the possible impacts of higher insurance prices on the uptake of such vehicles today, and on the costs to customers of additional technology as the standards increase in stringency through 2025. This higher cost is only further compounded by the extended financing terms likely to result from higher vehicle prices as customers must retain full insurance coverage on vehicles throughout the entire loan period.

Gasoline Price Estimates

Gasoline prices are a key component of any estimates for vehicle sales. Customer payback is tied to gasoline prices, and customer payback, along with the discount rate used by customers, enables a projection of future sales levels to be made. The Agencies rely on AEO2015 for the gasoline price projections in the Draft TAR. In several places, the Agenciespoint out the inability of AEO2011 to correctly anticipate the great decrease in gasoline prices in the 2014-2016 time period.[303] AEO2015 and AEO2016 incorporate the lower gasoline prices but project, as did AEO2011, that gasoline prices will immediately rebound and then resume to increase.

The Alliance associates the drop in gasoline prices with the advent of fracking in the oil well industry.[304] Fracking has resulted in the ability to produce more oil at lower cost from existing oil wells. And at the same time that fracking is applied to more and more wells, the science and methods of fracking continue to be developed. Horizontal fracking and other advances will continue to allow more and more oil to be pumped.[305] This leads us to suggest that the automatic rebound built into AEO2015 and AEO2016 may be premature and too great in size to represent a likely gasoline price scenario. NHTSA, in fact, anticipates the likelihood of such a scenario by including a Volpe low case fuel price for its CAFE modeling.[306] This is shown in the following Figure E-25:

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[303] 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, (EPA-420-D-16-900, July 2016) at 3-5, 13-80, 13-81, Figures 3.3, 13.13, 13.14.
[304] "Energy chart of the day: America's shale oil revolution will reverse a 40-year decline in crude oil output in just 5.5 years" U.S. Energy Information Administration. May 6, 2014. http://www.aei.org/publication/energy-chart-of-the-day-americas-shale-oil-revolution-will-reverse-a-40-year-decline-in-crude-oil-output-in-just-5-5-years/.
[305] Big Data Will Keep the Shale Boom Rolling. MIT Technology Review. June 2, 2015. https://www.technologyreview.com/s/537876/big-data-will-keep-the-shale-boom-rolling/.
[306] 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, (EPA-420-D-16-900, July 2016) at 13-90.

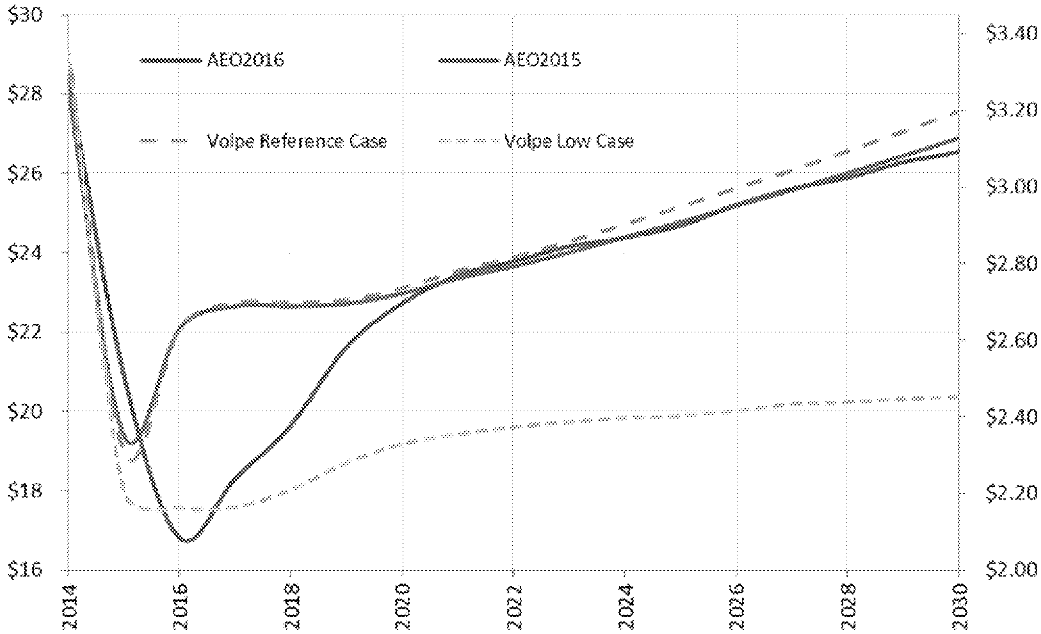

Figure E-25: Various Fuel Price Cases

We urge both Agencies to consider using the less rebounding, lower sloped Volpe Low Case gasoline scenario, for use in the modeling and sensitivity analyses in the next step of the MTE.

Impacts if Customers Are Unwilling to Pay

Decrease in New Vehicle Sales

EPA does not provide a quantitative estimate of the impact of the standard on overall employment because it claims it cannot estimate the output effect (i.e., the effect due to changes in vehicle sales only). The EPA analysis of employment effects is limited to partial assessment of substitution effects, which is insufficient to guide policy making.[307] We discuss the Agencies' shortcomings in estimating vehicle sales above in the section titled "Estimating the Impact of Higher Standards on Sales" and the effect of lower sales on employment in Appendix F: Employment Impacts.

Decreased Fleet Fuel Savings and CO2 Reductions

Additional impacts from customers purchasing fewer new vehicles include reduced turnover of the vehicle fleet, leading to longer retention of older, less efficient vehicles. If sales of highly efficient new vehicles are reduced, overall fleet fuel savings and CO_2 reductions will not be realized at the same rate. As is discussed above, the Agencies should estimate the impact of the

[307] *Id.* at 7-12.

standards on sales and compare fuel and CO_2 savings under the industry sales level associated with the reference MY2022-2025s scenario and savings under the industry sales associated with the MY2022-2025 standards.

Impacts on Used Vehicle Market and Access to Mobility

Experts have noted that used vehicle prices move in lockstep with new vehicle prices.[308]

As new vehicle prices increase due to the added cost of technology to comply with the GHG standards, the cost of used vehicles will increase with attendant effects on lower-income households. We therefore do not agree with Figure 6.1 in the Draft TAR which suggests that used-car prices will continue to decline. In fact, if over the long-term, new vehicle sales decrease, the supply of used vehicles is likely to remain flat or decrease, further placing upward pressure on the prices of used cars. Although customers may hold their vehicles for longer time periods, potentially increasing the average vehicle lifetime, fewer replacement vehicles would enter the used market. At the same time, if customers are pushed out of the new vehicle market into the used market, demand for used vehicles would increase, driving up prices.

Given these converging market forces, it is not clear to the Alliance how the Draft TAR can make a suggestion that used car prices will decline.

The Alliance commissioned a review of academic literature that sheds light on the impacts of the fuel economy standards on lower-income households.[309] This study finds that fuel economy standards have a disproportionate impact on low income households.

> Although it is generally believed that more stringent fuel economy standards and the accompanying increase in vehicle price and other ownership costs largely impacts only high income households, recently published, peer-reviewed research contradicts this conventional wisdom. University of California at San Diego Economics Professor Mark Jacobsen finds that fuel economy standards impose costs whose effects are 'sharply regressive,' requiring the poorest 25% of the population to incur [additional] ongoing/annual costs amounting to nearly three times the fraction of their incomes that the richest 25% have to pay.[310]

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[308] "Waiting for used-vehicle prices to fall? Not yet." Automotive News. September 8, 2016. Accessed September 26, 2016. http://www.autonews.com/article/20160908/RETAIL04/160909849/waiting-for-used-vehicle-prices-to-fall-not-yet.

[309] T. Walton, Defour Group. "The Impact of Future Fuel Economy Standards on Low Income Households." September 2, 2016. Attached as Attachment 11.

[310] *Id.* at 6.

Customers would be impacted by rising prices in the used vehicle market including reduced access to newer or more capable vehicles. The Agencies should study the impact of a decrease in industry sales on used vehicle pricing.

Recommendations

In addition to the customer acceptance issues described above, which the Alliance recommends the Agencies consider during the remainder of the MTE process, the Alliance has some additional specific recommendations to improve the Agencies' treatment of customer acceptance issues, discussed below.

Complementary measures to help drive customers to making the "right" decision

The Agencies should pursue measures to better align incentives in the marketplace with fuel efficient technologies. As discussed above, customers do not value fuel economy beyond limited payback periods, limiting the additional upfront investments they are willing to make to purchase fuel efficient vehicles and technologies. Incentives and other policies that reduce customer payback periods or lower the bar for investment in advanced technology vehicles are needed to expand customer adoption of these technologies. The Agencies should identify policy options for Congress, states, and other agencies to consider that would encourage customers to purchase fuel efficient vehicles, such as continued or expanded incentives for fuel efficient and alternative fuel vehicles.

Research NVES data to get better understanding of customer choices/decisions

Strategic Vision's New Vehicle Experience Study (NVES)[311] is a robust survey of new vehicle buyers, which provides insight into how customers make new vehicle purchasing decisions. The survey data can be mined and trended to infer, among other things:

- How new vehicle buyers rank fuel economy against other vehicle attributes
- What vehicle lines and segments customers choose when gasoline prices are high, or low
- What vehicle lines and/or segments customers buy given demographic and income characteristics
- Vehicle payment method, vehicle replaced, and future vehicle considerations

Access to similar data should give EPA insight into which types of customers are more likely to exit the pool of new vehicle buyers, or become unable to afford certain vehicle segments as new vehicle prices rise due to fuel economy requirements. Furthermore, this survey data would give EPA insight into customers' willingness to pay for fuel economy and/or willingness to compromise on vehicle choice. Finally, this data provides fresh evidence of how customers

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[311] "NVES." Strategic Vision. Accessed September 6, 2016. http://www.strategicvision.com/#!nves/fchi4.

behaved during two critical periods in the automotive industry, including the 2008-2009 recession, which reflected a period of high gasoline prices, as well as the most recent 2014-2015 period of low gasoline prices. The latter period, with gasoline prices below $3/gallon, has added further downward pressure on smaller car segments and electric vehicle demand as customer favor larger segments and CUV/SUV mixes.

Appendix F: Economic Assessment: Employment Impacts

As discussed in Appendix E of these comments, the Agencies have an obligation to consider economic factors. This Appendix will focus on one economic item in particular—employment impacts.

The greater automobile industry is a massive employer reaching well beyond the auto manufacturers. Auto manufacturing depends on a broad range of parts, components, and materials provided by thousands of suppliers, as well as a vast retail and vehicle maintenance network of dealers. Nationwide, eight million workers and their families depend on autos. Each year, the industry generates $500 billion in paychecks, while generating $70 billion in tax revenues across the country.[312] An accurate and thorough evaluation of employment impacts is critical for both the success the ONP and the continued health of the U.S. economy. Therefore, the Alliance encourages the Agencies to fully consider a peer-reviewed study that is taking place at the Indiana University School of Public and Affairs (IU) (IU Policy Paper) .[313]

In February 2016, the IU Policy Paper summarized the results of several recent employment studies that should have been considered in the Draft TAR.[314] The IU Policy Paper reviewed and identified limitations in some previous industrial impact studies. These limitations included the failure to consider the ZEV Program in conjunction with the federal standards; differing assumptions about the "green jobs" impact of regulation; the failure to understand state and regional impacts; and the failure to consider recent changes in global oil prices. The IU Policy Paper concludes that "methodological improvements are possible for new regulatory analyses in order to provide a more accurate and complete understanding of the macroeconomic effects of the federal and ZEV regulatory programs."[315] The study team made several preliminary recommendations for the MTE; it will issue a final report with quantitative analysis in January 2017. That analysis should inform the MTE.

The Agencies Acknowledge Their Responsibility to Estimate Employment Impacts

In determining appropriate changes to CAFE standards, and in determining appropriate levels for GHG standards, the Agencies are required to consider the impacts of the standards on employment and adjust the standards accordingly.

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[312] "Contribution of the Automotive Industry to the Economies of All Fifty States and the United States." Center for Automotive Research. 2015.
[313] Carley, *et al.* "Rethinking Auto Fuel-Economy Policy: Technical and Policy Suggestions for the 2016-2017 Midterm Reviews, Phase 1 Report." (Feb. 2016).
[314] *Id.*
[315] *Id.* at 42.

In acknowledging the need to consider employment impacts, the Draft TAR references the Presidential Memorandum that requires the Agencies to consider employment impacts when establishing the National Program. In acknowledging the need to consider employment impacts, the Draft TAR references the Presidential Memorandum that requires the Agencies to consider employment impacts when establishing the National Program. The Presidential Memorandum requested that Agencies develop the ONP to "strengthen the [auto] industry and enhance job creation in the United States."[316], states that, "Our regulatory system must protect public health, welfare, safety, and our environment while promoting economic growth, innovation, competitiveness, and job creation."[317] Acknowledging these goals, the 2012 FRM lists "[i]mpacts on employment, including the auto sector" as one of the factors to be considered in this Draft TAR."[318]

In addition to these statutory and regulatory imperatives, Executive Orders 13563 and 12866 require Agencies to provide a RIA for economically significant regulatory actions. While the Alliance understands that the Draft TAR is not the formal RIA that will be required before the Agencies take final action on the MY2022-2025 rules, the Draft TAR sets the table for the upcoming NPRM and accompanying RIA, and should therefore follow the same principles of regulatory cost-benefit analysis.

OMB Circular A-4[319] outlines the steps for an RIA. These include selecting a baseline that "represents the Agency's best assessment of what the world would be like absent the action"[320] and "using the best reasonably obtainable scientific, technical, economic, and other information to quantify the likely benefits and costs of each regulatory alternative."[321]

The Draft TAR Fails to Estimate Employment Impacts

The Draft TAR attributes possible employment effects to two factors: increases or decreases in vehicle sales (termed "output effects') and increased spending by automakers and suppliers to design, manufacture and install the technologies needed to meet the standards (termed "substitution effects"). Neither Chapter 7 (Employment Impacts) nor Chapter 13 (Analysis of Augural CAFE Standards) quantify sales changes due to the standards or employment changes in the automotive industry. Instead, the Draft TAR presents qualitative assumptions about how customer behavior may impact sales.

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[316] Executive Order 13563 , "Improving Regulation and Regulatory Review" (January 18, 2011)
[317] 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, (EPA-420-D-16-900, July 2016) at 7-1.
[318] 77 Fed. Reg. 62784 (Oct 15, 2012).
[319] Circular A-4. White House Office of Management and Budget. Accessed September 26, 2016. https://www.whitehouse.gov/sites/default/files/omb/assets/regulatory_matters_pdf/a-4.pdf.
[320] *Id.* at 4.
[321] *Id.* at 9.

The Draft TAR summarizes the Agencies' overall view of employment impacts by stating that in a full employment scenario, employment losses do not matter:

> In an economy with full employment, the primary employment effect of a rulemaking is likely to be to shift employment from one sector to another, rather than to increase or decrease employment…under conditions of full employment, any changes in employment levels in the regulated sector due to this program are mostly expected to be offset by changes in employment in other sectors.[322]

This approach, unfortunately, is similar to the approach taken in the 2012 FRM establishing the MY2017-2025 standards. At that time, the Agencies found sales "very difficult to predict," and concluded that because "sales have the largest potential effect on employment, the impact of this final rule on employment is also very difficult to predict."[323]

There is ample precedent, however, for the Agencies to consider impacts to employment and to make appropriate modifications to standards. In the past, NHTSA has considered impacts on employment due to proposed standards and has modified the standards to those impacts into account. Specifically, a thorough consideration of economic impacts was done in the analyses for the 1986 CAFE rules for cars and in the 1990 CAFE rules for trucks when the CAFE requirements were relaxed.[324] By not providing quantitative estimates of the output effect, and only a partial estimate of the substitution effect, the Agencies cannot reach a quantitative estimate of the overall employment effects of the final rules on motor vehicle sector employment or even whether the total effect will be positive or negative.

A recently released report, CAR report provides an estimate of employment impacts due to the CAFE and GHG standards.[325] The report first performs a broad review of previous academic studies and published literature on short-term and long-term price elasticities. Based on this review, the average long-run, own price elasticity for new vehicle sales revenue is estimated to be an average -0.61. Using this -0.61 elasticity value, Table 8 of the CAR study summarizes the results of nine potential scenarios in 2025, using $2,000, $4,000 and $6,000 vehicle price increases, and scenarios of $2.44, $3.00 and $4.64 per gallon gasoline prices.[326] For eight of the scenarios, vehicle demand is projected to decrease due to the higher vehicle prices, ranging from 370,000 to 3.7 million fewer sales. In only one scenario, where gasoline prices are projected to

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[322] 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, (EPA-420-D-16-900, July 2016) at 7-13 et seq.
[323] 77 Fed. Reg. 62623, 63112 (Oct. 15, 2012).
[324] 51 FR 35594 (October 6, 1986) and 53 FR 33080 (August 29, 1988)
[325] "The Potential Effects of the 2017-2025 EPA/NHTSA GHG/Fuel Economy Mandates on the U.S. Economy, September 2016." Center for Automotive Research. 2016.
[326] *Id.* at 42.

be high ($4.64 per gallon) and where vehicle technology costs are projected to be low ($2,000), is there a projected increase in sales (of 410,000 vehicles).

The CAR study estimates job losses from the projected sales decrease scenarios as 0.1 million (lowest sales decrease scenario) to 1.1 million jobs (highest sales decrease scenario) in the overall U.S. economy.[327]

Employment Changes Due to Substitution Effects Are Likely Overstated

The Draft TAR discusses possible employment effects based on two factors: effects on employment due to increases or decreases in vehicle sales (termed "output effects") and effects on employment due to increased spending by automakers and suppliers to design, manufacture, and install the FE technologies (termed "substitution effects"). Draft TAR, Chapter 7 begins the discussion of substitution effects, or the effects using estimates of the historic share of labor as a part of the cost of production. These historic shares of labor are extrapolated based on the increased cost of production, *i.e.*, X increase in cost of production is extrapolated to Y increased cost of labor, which is then made equivalent to Z change in labor headcount. The Agencies state that this will only "provide a sense of the order of magnitude of expected impacts on employment…"[328] Nevertheless, the Agencies extrapolate the potential increased employment based on Table 7.2, which shows an extrapolation from $14.7 billion in increased compliance costs to a range of 1,200 to 11,800 added workers in 2025.

This extrapolation is based on a historic share of labor from the Bureau of Labor Statistics Employement Requirement Matrix data in combination with the Annual Survey of Manufacturers and Economic Census data and then (likely) adjusted for productivity improvements based on historical trends of a 6.6% per year productivity improvement in the Motor Vehicle Manufacturing Sector, and a 4.9% per year improvement in the Motor Vehicle Parts Manufacturing Sector.[329]

Even though this extrapolation accounts for historically accurate trends in the productivity increases, it does not likely capture historic secular trends that are occurring in the automotive industry, largely as a result of the extreme fuel economy increases required by the rules. In the 2012 FRM, the EPA titled such changes "factor shift effect,"[330] but in the end determined not to modify historic shares of labor based on trends. Factor shift effects are shifts in the historic ratio of labor-to-part cost. It is clear that some technologies will require significantly less labor than

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[327] *Id.* at 49.
[328] 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, (EPA-420-D-16-900, July 2016) at 7-8.
[329] *Id.* at 7-9.
[330] 77 Fed.Reg. at 62956.

other equivalently effective technologies, and it is also clear that some of those types of technologies will be relied upon much more in the future. Thus, the Agencies should address (in the next step of the MTE) factor shift effects due to reasonably anticipated declines in labor content of certain technologies, by, as an example, extrapolating and comparing the direct labor costs from the FEV teardown studies performed for fuel economy technologies considered in the 2012 FRM.

For instance, the reasonably anticipated increase in the number of electrified platforms needed to achieve the 2025 standards will significantly deviate from the historic ratio of labor-to-part cost in several ways. Electrified platforms will use large, consolidated assemblies, such as EV/HEV/PHEV battery packs and electric motors, which could achieve a large FE increase with a lower increase in labor cost, as compared to, for instance, incremental approaches to improving powertrain efficiency. It is clear that labor is a small share of the cost of a battery as shown in Figure F-1.

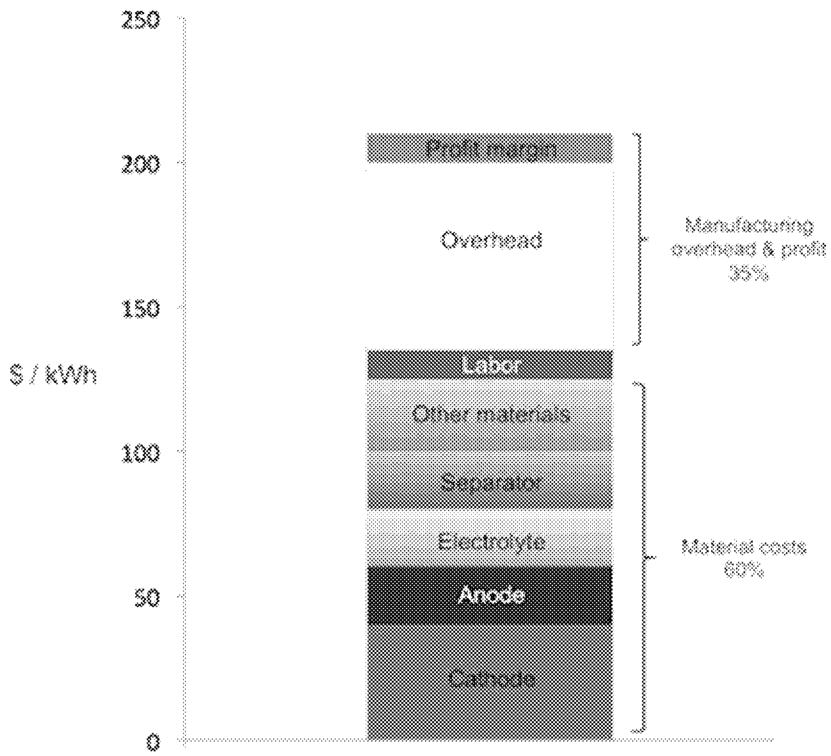

Figure F-1: Breakdown in Battery Cost Contributors[331]

[331] The Cost Components of a Lithium Ion Battery. Qnovo. Accessed September 26, 2016. http://qnovo.com/82-the-cost-components-of-a-battery/.

In addition to the reduced labor content of the large consolidated parts used in EVs, Tesla is planning to pioneer an assembly line for production of the Model 3 that eliminates all labor for EV assembly.[332] You really can't have people in the production line itself,' said Musk."[333]

Already Tesla's changes to the way vehicles are sold and distributed are heralding a reduction in the labor content at dealerships necessary to sell and service EVs.[334] A dealership in Ohio, notes that "[i]f other carmakers followed Tesla, essentially, it would put us out of business."[335] The Agencies can reasonably conclude that significant declines in labor content are possible with the introduction of EVs and should account for these decreases in the NPRM.

Employment Changes Due to Fuel Savings Being Spent in the General Economy Are Likely Overstated

In the 2012 FRM, the Agencies declined to quantify multiplier effects (e.g.,customers spending their fuel savings in the general economy and thereby increasing employment in the general sector) stating, "[w]e do not quantify multiplier effects, due to uncertainty over the state of the economy at the time this rule takes effect as well as the market evolutions that are likely to occur between now and implementation."[336]

The Draft TAR notes that "consumer spending is expected to affect employment through changes in expenditures in general retail sectors; net fuel savings by consumers are expected to increase demand (and therefore employment) in other sectors"[337] but does not attempt to further quantify that effect.

The Draft TAR pre-qualifies the amount of the stimulus that would be available by stating, "[a]s a result, consumers are expected to have additional money to spend on other goods and services, though the timing for access to that additional money depends on the payback period…"[338]

This means that employment stimulus due to fuel savings must wait until payback is achieved. However, due to low gasoline prices and high vehicle compliance costs, using EPA's payback calculations in Table 12-52, payback is only achieved (using EPA's compliance cost estimates)

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[332] Elon Musk: Tesla's Model 3 factory could look like an alien warship. The Washington Post. Accessed September 26, 2016. https://www.washingtonpost.com/news/the-switch/wp/2016/08/04/the-future-of-car-production-will-be-devoid-of-people-according-to-tesla/.
[333] *Id.*
[334] The battle between Tesla and your neighborhood car dealership. The Washington Post. Accesed September 26, 2016. https://www.washingtonpost.com/business/economy/the-battle-between-tesla-and-your-neighborhood-car-dealership/2016/09/09/55fb1878-6864-11e6-99bf-f0cf3a6449a6_story.html.
[335] *Id.*
[336] 77 Fed. Reg. at 62953 (October 15, 2012).
[337] 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, (EPA-420-D-16-900, July 2016) at 7-14.
[338] *Id.* at 7-13.

after five years of ownership.[339] This means, of course, that any employment stimulus due to fuel savings must wait five years.

This is also assuming that the vehicle is purchased in the first place, a questionable assumption in light of evidence that customers only consider the first three years of fuel savings in any prospective purchase payback calculation.[340]

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339 *Id.* at 12-43.
340 "Cost, Effectiveness and Deployment of Fuel Economy Technologies for Light-Duty Vehicles." National Academy of Sciences, National Research Council to the National Academies. 2015. 317.

Appendix G: Regulatory Elements Necessary for Compliance

Mobile Air Conditioning (MAC)

The Alliance believes that MAC improvements will continue to contribute to lower greenhouse gas emissions and reduced fuel consumption. To better realize MAC improvements, the Alliance proposes the following recommendations regarding the system of MAC credits including:

- EPA should consider adjusting MAC credits upward to reflect more accurate information on actual air conditioner usage.
- EPA should consider simplifying and standardizing the procedures for claiming off-cycle credits for the new MAC technologies that have been developed since the creation of the MAC indirect credit menu.
- EPA should consider simplifying and streamlining its review and approval processes to create new credits for additional technologies under the off-cycle credit provisions, without maintaining prohibitive testing burdens for every case-by-case credit application.
- The EPA should consider removing the cap on low-leak credits, since it limits the incentive to achieve the maximum achievable emission reductions in this area.
- EPA should consider eliminating the penalty of up to two grams CO_2 per mile for systems that use R-1234yf (or other low-global warming potential (GWP) refrigerants) but fails to achieve certain low-leak levels.

These issues are explained in further detail below.

MAC Efficiency

In the 2012-2016 light-duty GHG and CAFE regulation (2010 FRM)[341] EPA created a list of efficiency technologies which could earn a pre-defined and pre-approved credit in grams per mile of CO_2.[342] These were termed "indirect" MAC credits, since the emissions reduction did not result within the air conditioner system itself, but rather from the savings in fuel ultimately used to power the MAC system. The baseline for these credits was EPA's estimate of the total fuel usage (and hence indirect emissions) from light-duty mobile air conditioner usage in the U.S., which EPA estimated to be 14.3 grams CO_2 per mile, or 3.9% of total national light-duty vehicle fuel usage.

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[341] "Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards; Final Rule". 75 Fed. Reg. 25324 (May 7, 2010).
[342] Id. at 25428.

The technologies identified for pre-approved credits and the percentage efficiency improvement estimates for these technologies came primarily from the Improved Mobile Air Conditioner (IMAC) industry-government Cooperative Research Program conducted through SAE International. IMAC was a partnership between EPA, DOE and 28 corporate sponsors, which published its final report in 2006.[343] The IMAC program demonstrated an improvement of 36.4% in MAC efficiency using best-of-the best designs for these technologies on a test vehicle, compared to a baseline MAC system using a defined list of typical technologies in production at that time, such as a fixed displacement compressor.[344] Based primarily on the IMAC report, EPA estimated that a 40% MAC indirect emissions reduction was possible using the technologies on the pre-approved list, and set a cap on these credits based on a 40% improvement level, equating to a cap of 5.7 grams CO_2 per mile.[345]

The pre-defined and pre-approved MAC indirect credit menu has proven to be a highly successful approach for gaining rapid implementation of air conditioner efficiency technologies. Air conditioner efficiency technologies were not heavily used among vehicles sold in the U.S. at the beginning of the greenhouse gas regulatory period, with the total industry claiming only an average of 1.0 gCO_2/mile in CO_2 credits in 2009. Since then, manufacturers have claimed credits significantly faster than assumed by EPA when the Agency drafted the 2012-2016 standards, rising to an average industry credit of approximately 3.4 gCO_2/mile in 2014. This is 60% of reaching the maximum capped credit level of 5.7 gCO_2/mile. MAC indirect credits are playing a critical role in industry compliance with the light-duty vehicle GHG regulation, achieving emission reductions that would not otherwise have been possible using the previous CAFE regulatory framework.

EPA has acknowledged the importance MAC credits as a significant source of real-world benefits:

> About 40 percent of these [credits] were accrued through the use of the optional credit programs for air conditioning systems, indicating a significant, real-world benefit as a result of the introduction of the technologies underlying these optional credit programs.[346]

The Draft TAR states:

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[343] SAE International. Refrigerant Leakage Reduction. IMAC Team 1 Final Report. 2007.

[344] "Final Rulemaking to Establish Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards, Regulatory Impact Analysis." U.S. Environmental Protection Agency. EPA-420-R-10-009. April 2010. 2-30.

[345] This cap was subsequently modified by the MY2017-2025 rulemaking to 5.0 grams CO_2 per mile for cars and 7.2 grams CO_2 per mile for light trucks, starting with MY2017 to more accurately align the improvements based on the physics of the vehicles.

[346] "Greenhouse Gas Emission Standards for Light-Duty Vehicles: Manufacturer Performance Report for the 2012 Model Year." U.S. Environmental Protection Agency. 2014. 11.

> Many manufacturers have taken advantage of the A/C credit program to generate and bank A/C efficiency credits, which have become an important contributor to industry compliance plans. As summarized in the EPA Manufacturer Performance Report for the 2014 model year, 17 auto manufacturers included A/C efficiency credits as part of their compliance demonstration in the 2014 model year. These amounted to more than 10 million Mg of credits, or about 25 percent of the total net credits reported. This is equivalent to about 3 gCO_2/mile across the 2014 fleet.[347]

Looking forward, the Draft TAR also states:

> Additional information that has become available, as well as changes in the overall regulatory environment affecting the A/C technology developments in the light-duty vehicle industry, reinforces our earlier conclusions that these technologies will continue to expand and play an increasing role in overall vehicle GHG reductions and regulatory compliance.[348]

EPA based its MAC efficiency credits on estimates of each technology's percentage impact on the total fuel usage by vehicle air conditioner systems in the U.S. However, EPA's estimate of baseline air conditioner energy usage (3.9% of total light-duty fuel consumption) was well below the estimates of others, such as researchers from the National Renewable Energy Laboratory (over 6%) and Oak Ridge National Laboratory, as well as longstanding benchmarks used by industry. The Alliance continues to believe that this low baseline used by EPA, which was approximately half the baseline MAC energy usage estimated by the other major sources, resulted in MAC efficiency credits and an associated credit cap which are far below the actual real-world fuel savings and CO_2 reductions that are resulting from these technologies. At a minimum, the existing MAC indirect credit system cannot be viewed as excessive or overly generous. Instead, as a result of the EPA methodology, these credit amounts were set at very conservative levels.

Since the 2007 publication of the IMAC final report and 2010 FRM[349] (with its indirect MAC credit menu), additional MAC technological progress has occurred. Automobile manufacturers hope to expand on the success of the MAC indirect credit menu by earning credits for these more recent technological developments, thereby accelerating the adoption of the new technologies. The off-cycle greenhouse gas credit provisions provide a means to do this since additional MAC

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[347] 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, (EPA-420-D-16-900, July 2016) at 5-210.
[348] *Id.* at 5-208.
[349] "Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards; Final Rule". 75 Federal Register 25324 (May 7, 2010).

efficiency technologies are listed as eligible for credits under the off-cycle provisions. Automakers request that EPA simplify and standardize the procedures for claiming off-cycle credits for the new MAC technologies that have been developed since the creation of the MAC indirect credit menu. The variable crankcase suction valve technology provides a case study for potential improvements.

Variable CS Valve Compressor

The variable crankcase suction valve for MAC compressors provides an example of the potential for additional emissions reductions in this area and the regulatory improvements that can be made to help achieve these reductions. On September 1, 2015, General Motors was granted 1.1 grams CO_2 per mile per vehicle in off-cycle credits for its use of an improved air conditioner compressor with variable crankcase suction valve technology.[350] The Denso SAS compressor is a new Externally-controlled Variable Displacement Compressor (EVDC) design that improves the internal valve system within the compressor to reduce the internal refrigerant flow necessary throughout the range of displacements that the compressor may use during its operating cycle. This is achieved though the addition of a variable crankcase suction valve (variable CS valve). Conventional compressors have a fixed crankcase to suction bleed that regulates the flow of refrigerant exiting the crankcase. The sizing of the bleed is a compromise among the conditions when either a high rate of flow or a low rate of flow would be more ideal. In conditions where maximum air conditioner capacity is not needed, this fixed bleed creates an unnecessary reduction of volumetric efficiency for the compressor. In contrast, a variable CS valve can provide a larger mass flow under maximum capacity and compressor start-up conditions, when high flow is ideal; it can then reduce to smaller openings with reduced mass flow in mid or low capacity conditions. Thus, the volume of refrigerant exiting the crankcase is optimized across the range of operating conditions, creating significant benefits for the energy consumption of the air conditioning system.

The Denso SAS compressor initially used on the 2013 Cadillac ATS was evaluated using the methodologies that were developed and used during the SAE IMAC Cooperative Research Program for its evaluations of U.S. average system efficiency. These methodologies were subsequently adopted as SAE standards. The SAE J2765 standard specifies a series of bench tests at various compressor speeds to measure the system coefficient of performance (COP). Among these bench test conditions, 25 are then selected as inputs to the Global Refrigerants Energy and Environmental (GREEN) MAC Lifecycle Climate Change Performance (LCCP) model jointly developed for comparative evaluations by General Motors, EPA, the Japanese Automobile Manufacturers Association, and SAE . These 25 data points replicate a broad range

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[350] "EPA Decision Document: Off-cycle Credits for Fiat Chrysler Automobiles, Ford Motor Company, and General Motors Corporation." U.S. Environmental Protection Agency. EPA-420-R-15-014. September 2015.

of operating conditions for various ambient climate conditions and air conditioner system modes. This LCCP model was adopted as the SAE J2766 standard.

The GREEN MAC LCCP model includes U.S. climate data for numerous U.S. cities as well as vehicle on-road operation parameters. Some of the key parameters are temperature and humidity data from a U.S. Department of Energy (DOE) database that contains U.S. National Climatic Data Center data, annual driving distances for each city from the EIA, and percentage of drive time at different ambient conditions based on research by the National Renewable Energy Laboratory (NREL). Combining the J2765 bench test COP data with the NREL, EIA and DOE climate and vehicle on-road data provides a simulation of annual U.S. average greenhouse gas emissions for an air conditioning system.

This full analysis was performed for the Denso SAS compressor with variable CS valve technology. The same analysis was then performed for the Denso SBU compressor, which is a modern EVDC design that does not have the variable CS valve. The SBU compressor was used at that time on a wide variety of vehicles. It qualified for the 1.7 grams CO_2 per mile MAC credit under the EPA regulation for an EVDC compressor with Reduced Reheat, and, as such, constituted a valid comparative baseline to determine if the SAS compressor with variable CS valve technology deserved an additional off-cycle credit for emission reductions beyond those already achieved by compressors that qualify for the EPA EVDC MAC credit from the pre-approved credit menu. (Both compressors also feature integrated oil separators, and both qualify for the MAC oil separator credit of 0.6 grams CO_2 per mile.) Using the techniques from SAE standards J2765 and J2766, an improvement percentage was estimated for the SAS compressor with the new technology. This improvement percentage was then applied to the baseline EPA estimate of U.S. MAC fuel usage of 14.3 grams CO_2 per mile to calculate that the SAS compressor with variable CS technology deserved an off-cycle credit of 1.1 grams CO_2 per mile.

This credit amount was also confirmed in vehicle AC17 tests which compared the energy consumption of the same vehicle when equipped with the SAS compressor to the SBU compressor. As was noted in the credit application, it was a very rare coincidence that this vehicle A-to-B AC17 testing could be conducted. In this case, General Motors happened to have two nearly identical compressors with the same mounting points, connection points, controls and other attributes–varying only in that the SAS compressor had the variable CS technology, while the SBU compressor did not.

Compressors with the variable CS valve technology are available in the marketplace for other automobile manufacturers, and the implementation of this beneficial technology could be accelerated throughout the industry if EPA made off-cycle credits for it more readily available. The benefits could be reliably assessed by each manufacturer solely using bench test data according to the SAE J2765 and J2766 standards. Instead, EPA has insisted that each manufacturer also conduct the more difficult vehicle AC17 A-to-B tests. The Alliance believes this is an unnecessary double layer of testing. The AC17 A-to-B testing has proven to be a prohibitive testing requirement for other manufacturers, since it is not typical for a manufacturer to have two nearly identical compressors that can be fitted into a test vehicle to measure the benefits of the variable CS valve. This is an example where EPA could simplify its requirements to improve operation of the off-cycle credit program, without reducing the integrity of the program in providing real-world emissions reductions. Note that the credit was calculated as a percentage of the conservative EPA 14.3 grams CO_2 per mile baseline for MAC usage, meaning that the real-world emissions reductions from the technology are likely more than the credited amount, making it especially unfortunate that this technology opportunity has not been expanded throughout the industry with more accessible off-cycle credits.

Even more problematic, the text of the Draft TAR raises another barrier which had not previously been encountered, when it makes reference to an apparently new requirement that new MAC efficiency technologies approved for credit under the off-cycle credit provisions will fall under the same MAC credit cap that had been created in the 2012 FRM based on the 40% improvement documented for the credit menu technologies that had been assessed by the 2006 IMAC cooperative research program. EPA states, "[a]pplications for A/C efficiency credits made under the off-cycle credit program rather than the A/C credit program will continue to be subject to the A/C efficiency credit cap."[351]

We believe that this Draft TAR statement has been made erroneously, since no limit of this type for new MAC efficiency technologies had ever previously been stated. The discussion about the cap in the RIA for the 2012 FRM was concerned with interactions among the technologies being evaluated at that time. These technologies had been collectively assessed in the IMAC cooperative research program to give an improvement on the demonstration vehicle of nearly 40%, whereas the individually assessed benefits used on the pre-approved credit list would add up in total to an improvement of over 40%. Specifically, there are a total of 7.1 grams of CO_2 per mile in potential indirect credits on the original 2012-2016 MAC indirect credit list, if the maximum were achieved in each category. This compares to a baseline of 14.3 grams of total MAC usage. The 7.1 grams would have equaled a reduction of 50% of the baseline, and so a cap that was established of 5.7 grams to limit the potential credits from these technologies to 40% of the baseline. It was never stated that this cap would also cover any additional MAC efficiency technologies which might be developed in the future.

Furthermore, it would be counterproductive to create such a limit on credits for future technologies, since it would forestall any improvements in MAC efficiency beyond the technologies which are already on the MAC indirect credit menu. Indeed, the cap on indirect

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[351] 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, (EPA-420-D-16-900, July 2016) at 5-210.

MAC credits is already below the level that could be earned through maximum implementation of all the technologies on the current credit list, so there is already some loss of incentive to maximize the use of MAC efficiency technologies. These caps contradict and undermine the Agencies' statements that MAC technology developments will continue to expand and play an increasing role in overall vehicle GHG reductions.

Instead, off-cycle technologies that have been individually demonstrated to earn credits under the off-cycle program, by producing incremental emission reductions beyond those of the pre-approved technologies, should be free from the credit caps that were created seven years ago for the defined list of pre-approved technologies that were known at that time.

The General Motors analysis for the off-cycle credit for the SAS compressor with variable CS valve technology clearly showed that the energy savings were incremental to a baseline compressor (the SBU compressor) that had all of the compressor efficiency technologies on the MAC indirect credit pre-approved menu. In general, credit caps are counterproductive since they impede greater technology implementation. Certainly in the case of new MAC (or other off-cycle) technologies which have been specifically demonstrated to be incremental to the technologies on the pre-approved list, the caps created based on the pre-approved list should not be applied. In addition, there have been many new efficiency improvement technologies presented in various technical forums, such as at the SAE World Congress and the SAE Thermal Management System Symposium, which would increase efficiency significantly beyond the MAC indirect credit menu. Evaluations of some of these new technologies have been presented by National Laboratories such as NREL and Oak Ridge, in addition to presentations by automakers and MAC suppliers. These additional MAC efficiency technologies offer substantial additional greenhouse gas reductions, and Agency policies should try to encourage and incentivize rapid implementation of these improvements.

In summary, the MAC credit program has been a success in accelerating real-world emissions reductions, and MAC credits are essential for compliance with the EPA regulations. In fact, there is a strong basis to conclude the real-world benefits have exceeded the credited amounts. Creating the list of pre-defined and pre-approved credits was the cornerstone of this success, but the program should not be permanently limited to the technologies on the 2012 list. EPA should simplify and streamline its review and approval processes in order to create new credits for additional technologies under the off-cycle credit provisions, without maintaining prohibitive testing burdens for every case-by-case credit application. Also, the cap for the MAC indirect credits cannot be applied to include additional MAC efficiency technologies that may be developed in the future.

AC17 Test

The Draft TAR presents a fairly comprehensive and well-informed review of issues related to the AC17 test of MAC efficiency.[352] This reflects the close dialogue on these issues that EPA has maintained with the industry since the 2004-2006 IMAC SAE Cooperative Research Program and the subsequent early stages of development of the MAC indirect GHG credits. Continued dialogue and cooperation between the Agencies and industry is encouraged to assure the success of the MAC credit program. The Draft TAR review included the inherent test-to-test variability of the AC17 procedure, which can at times exceed the relatively small benefit of the technologies under consideration. It also referenced the impossibility in some cases of obtaining baseline MAC systems to use in conducting A-to-B testing to compare to a new and improved system. The overarching conclusions were that the evaluations of the AC17 procedure are not yet complete and are not yet conclusive.[353]

Stated slightly differently, the AC17 MAC efficiency test has not proven that it can play the role that EPA envisioned for it in their GHG regulation beginning in 2020 model year, when the A-to-B AC17 tests would need to show a differential sufficiently large for a manufacturer to apply the indirect MAC credit from the list of pre-approved technologies. There are too many testing difficulties for the AC17 procedure to function on a stand-alone basis in the way that traditional emissions certification tests measure compliance compared to a standard. Instead, the experience gained over the past few years with the AC17 procedure shows that it can best be used as a *supplement* to evaluations of the efficiency of an air conditioner technology, rather than as the sole basis for measuring efficiency.

Therefore, it can be expected that in almost every compliance submission beginning in 2020, manufacturers will need to submit an engineering analysis (rather than straightforward AC17 test results) in order to meet the A-to-B comparison requirements to justify their MAC indirect credits. This engineering analysis may or may not be supplemented with AC17 A-to-B testing of some or all of the technologies in the credit requests for each vehicle. The same logic applies to other uses of the AC17 test, such as for evaluating new MAC efficiency technologies as potential off-cycle credits, as was done by General Motors using the Denso SAS compressor with variable CS valve technology. The AC17 test can supplement these evaluations, but should not be used as an essential requirement for every credit submission. For example, the AC17 test only covers a limited set of the conditions that can occur in the real world, whereas future technologies may be developed that only provide their benefits in these other conditions not experienced in the AC17 test. Engineering analysis using bench test data or other approaches may be sufficient, or even superior, for these evaluations.

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[352] *Id.* at 5-209 et seq.
[353] *Id.* at 5-215.

The Draft TAR describes some of the activities being conducted through SAE to define other methodologies to support these A-to-B engineering analyses, such as SAE standards for bench testing the efficiency of an IHX (internal heat exchanger), an oil separator, an improved evaporator or condenser, or a blower controller.[354] It also describes the possibility of including some of these newer methodologies in a guidance document on this issue, which would be a useful document to bolster confidence for investment in these technologies.

It should be noted that other nations such as the Kingdom of Saudi Arabia and the Republic of Korea have adopted MAC indirect credit provisions into their new GHG regulations, patterned after the U.S. EPA regulation. However, the timing is different, and Saudi Arabia requires A-to-B testing as early as 2018, instead of the U.S. schedule to begin this requirement in the 2020 model year. This raises the urgency of clarifying and resolving these issues, such as by issuing an EPA guidance document within the next few months that could assist implementation in the U.S. as well as other nations that are following the U.S. regulatory format.

Finally, it should be remembered that the pre-approved credit list in the MAC indirect credit program has over the past several years been working very well to accelerate the implementation of more efficient air conditioner technologies. Due to its small baseline for MAC energy usage, the EPA methodology for creating these pre-approved credits was very conservative, and real-world emissions reductions likely exceed the credited amounts. Viewed from this perspective, the upcoming A-to-B testing requirements pose more of a barrier to these emissions reductions than they create an opportunity for improving the program. The 2020 AC17 A-to-B test requirement could create uncertainty over full achievement of MAC indirect credits that could hinder investment in MAC efficiency technologies. If compliance with the A-to-B requirements becomes overly problematic, there could be backsliding on the technological progress that is currently underway. The future success of the MAC credit program in generating emissions reductions will depend to a large extent on the manner in which it is administered by EPA, especially with respect to making the AC17 A-to-B provisions function smoothly, without becoming a prohibitive obstacle to fully achieving the MAC indirect credits.

Alternative Refrigerants and Refrigerant Leakage

As with the MAC indirect credits, the MAC direct credits have been a success in accelerating real-world GHG emissions reductions. The MAC direct credits are related to leakage of vehicle air conditioner refrigerants and the associated global warming impact of these chemicals. In the early years of the program, alternative refrigerants were not available, and credits could only be earned through tightened air conditioner systems that reduced leakage of the existing refrigerant, R-134a. This happened quickly, such that:

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[354] *Id.* at 5-215.

> Leakage reduction improvements increased 69% to 10.3 million mega grams in only three years, from 2009 to 2012. The increase on a per vehicle basis was from approximately 3.5 grams per mile of CO_2 per vehicle in 2009 to approximately 4.0 grams per mile in 2012.[355]

Meanwhile, a new low GWP air conditioner refrigerant was developed, R-1234yf, which was introduced on new vehicles in the U.S. beginning in the 2013 model year. R-1234yf has a GWP approximately equal to CO_2, meaning its GWP is 1. Since there is a range of only one to three pounds of refrigerant in typical vehicle air conditioner systems, and this refrigerant charge provides for operation over many years, the use of a refrigerant with a GWP as low as that of R-1234yf essentially removes vehicle air conditioner refrigerants from the list of meaningful contributors to GHG emissions, and moves refrigerant direct emissions into a *de minimis* category, equating to only a few grams per year per vehicle of CO_2-equivalent.

Global production capacity for R-1234yf has increased steadily, and there are currently approximately 40 million vehicles on the roads globally using R-1234yf.[356] The incentive created by pre-defined MAC credits has accelerated the U.S. HFC reduction program into a leading position worldwide, laying the groundwork for eventual phase-down of high GWP automotive refrigerants. Building on the success achieved through the MAC direct credit program, in 2015, EPA changed the SNAP listing status of R-134a refrigerant, such that it will no longer be allowed on new light-duty vehicles in the U.S. beginning in the 2021 model year.[357]

Despite the success of the MAC direct emission credit program, there are opportunities for improvements to the regulations that would provide even greater success. For example, the caps on the low leak credits for each vehicle eliminate any incentive to use leak reduction technologies to the maximum extent. The leakage scores are calculated according to SAE standard J2727, which estimates leakage based on factors such as the lengths of air conditioner hose in the system, hose materials, number of joints, types of seals used for each joint, and the type of compressor shaft seal. Examination of the J2727 scoring system reveals how it is possible to use the best technologies in each category (for hose material choice, joint seal design, compressor shaft seal design, etc.) and achieve leak rates that are below the level that is granted the maximum EPA MAC low-leak emission credit. There is no good reason for the cap on low-

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[355] "Greenhouse Gas Emission Standards for Light-Duty Vehicles: Manufacturer Performance Report for the 2012 Model Year." U.S. Environmental Protection Agency. 2014. 29.
[356] An Estimated 18 Million Cars Using 1234yf by End of 2016. Chemours. Accessed September 26, 2016. https://www.chemours.com/Refrigerants/en_US/uses_apps/automotive_ac/SmartAutoAC/18-million-cars/index.html.
[357] 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, (EPA-420-D-16-900, July 2016) at 10-48.

leak credits, since it limits the incentive to achieve the maximum achievable emission reductions in this area.

Finally, a penalty of up to 2 grams CO_2 per mile was put into the regulation for systems that use R-1234yf (or other low-GWP refrigerants) if they do not achieve certain low-leak levels. This penalty is overly large in comparison to the *de minimis* GWP impact of the refrigerant that could possibly leak under these circumstances. However, the main problem with these provisions is that the penalty system, created to maintain high levels of MAC system integrity, is not needed in view of the high cost of R-1234yf refrigerant. We believe that due to this high cost, the industry has adopted demanding specifications for R-1234yf system integrity in order to reduce warranty and other costs, compared to historical design standards for R-134a and R-12 systems. Thus, we believe that these provisions are a reporting burden that will not create any real-world benefits that could justify its existence.

Off-Cycle Credits

The Agencies have often acknowledged the benefits of providing the opportunity for manufacturers to generate off-cycle credits.[358] These technologies result in real-world benefits in reducing GHG emissions and fuel consumption that are not adequately captured on the current test procedures. The off-cycle program allows for additional compliance options and flexibilities that give manufacturers the opportunity for supplementary compliance actions. The off-cycle program is also in a unique position to incentivize technologies that may not otherwise be developed, due to not being fully represented on the two-cycle test procedure. These technologies have the potential to provide significant real-world reductions as the benefits are modeled around real-world conditions rather than a specified test procedure. Thus technologies which are demonstrated to provide real-world emission reduction benefits should be applicable to the off-cycle program.

Significant volumes of off-cycle credits will be essential for the industry in order to comply with the GHG and CAFE standards through 2025. The Agencies included off-cycle credits from only two technologies in their analyses for setting the stringency of the standards (engine stop start and active aerodynamic features). However, because the fuel consumption benefits of many other technologies were overestimated in the Agencies' analyses, and the standards were therefore set at very challenging levels, off-cycle technologies and the associated GHG and fuel economy benefits are viewed by the industry as a critical area that must become a major source of credits.

The early industry activity in this new category of regulation indicates its importance and shows the growing resources that are being shifted towards achieving emissions reductions using off-

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[358] *Id.* at 5-218.

cycle technologies. Following the first year of the pre-defined off-cycle credit menu, EPA noted that off-cycle credits had already become significant for some manufacturers, and that some would be expected to reach eventually the 10 gram cap for credits from the pre-approved off-cycle credit list.[359] In fact, the U.S. total fleet average off-cycle credit level is reported to be 2.3 grams CO_2 per mile in 2014.[360] This is much higher than the level of off cycle credits five years previously, in the first year of the LDV GHG regulatory program.

The creation of the pre-approved credit list for 2014 and later years has become the source of the greatest success for the off-cycle credit program. This list of pre-defined and pre-approved credits is stimulating widespread investment by the industry in emission reduction technologies which would not have been impacted by the traditional two-cycle, city/highway, fuel economy regulatory framework that has existed for the past 40 years. This growing dedication of resources by the industry to the pre-approved technologies on the list can be expected to greatly accelerate the pace of technology improvements in the next several years.

The most important off-cycle priority going forward will be to maintain the reliability and credibility of the pre-defined technology credit list as the basis for making these long-term investments in new technologies. In part, this means during the administration of the off-cycle compliance reporting process not inserting additional unanticipated requirements or restrictions such as performance testing, caveats or narrow interpretations of the technology definitions. The technology definitions in the regulation were created with an intention to be broadly inclusive of experimentation and differing approaches by the various manufacturers in this new area of regulatory activity. At this time, at least through the first stages of building the off-cycle program, this concept of openness to differing approaches should be maintained. As credit opportunities are identified and become proven, new technologies can be expected to be implemented, and then continuously improved. The industry needs to be able to rely 100% on the pre-defined and pre-approved off-cycle technology credit list as the basis for making investments to implement these technologies.

The Alliance's recommendations related to off-cycle credits include the following:

- The caps on off-cycle credits from the pre-approved list should be eliminated.
- If the off-cycle credit caps are not eliminated, they could be made less constraining if they were administered as fleet average credit caps, rather than per-vehicle caps.
- Off-cycle credit applications should be simplified and processed more quickly.
- EPA should examine additional technologies for potential inclusion onto the list of pre-approved off-cycle credits.

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[359] *Id.* at 5-223.
[360] "Greenhouse Gas Emissions Standards for Light-Duty Vehicles: Manufacturer Performance Report for the 2014 Model Year." EPA-420-R-15-026. December 2015. 40. Table 3-21.

- EPA should revisit certain technologies to increase their credit values, such as stop-start, in view of the considerable information on higher real-world idle times that has been gained since the original default stop-start credit was calculated for the pre-approved credit list.
- EPA and NHTSA should begin the technical studies to support the next generations of innovative fuel savings technologies, and develop off-cycle credit frameworks to accelerate their implementation.
- The program could be further stimulated through the use of credits for the early achievement of especially ambitious goals.
- EPA should consider adopting certain eco innovation greenhouse gas technologies approved by the European Union (E.U.) into the off-cycle credit system.
- EPA should revisit the minimum penetration thresholds and the required CO_2 improvement thresholds within the advanced technology pickup program and should extend the credits beyond their current timeframe; we also recommend that the Agencies consider whether this technology should be applied to other light-duty trucks.
- EPA and NHTSA should begin the technical studies to support the next generations of innovative fuel savings technologies associated with safety and congestion mitigation from improved vehicle-to-vehicle and vehicle-to-ground communication, as well as from car-sharing and car-hailing services, and develop off-cycle credit frameworks to accelerate their implementation prior to model year 2026.

These issues are explained in further detail below.

Credit Caps

With the pre-approved credit list properly administered, the off-cycle program can be expected to grow toward the credit caps that were established in the regulation, and these credit caps will become binding constraints for many or most automobile manufacturers. At that point, the credit caps will be counterproductive since they will impede greater implementation of the beneficial off-cycle technologies.

Some hypothetical scenarios reveal how easily a manufacturer could be constrained from maximum implementation of off-cycle emissions reduction technologies by the 10.0 grams CO_2 per mile fleet average cap that was set for credits from the pre-approved list. Passenger cars typically have smaller off-cycle credits than the truck credits on the list. Even so, a manufacturer would exceed the 10-gram cap if it implemented on all its cars a program to apply across-the-board stop-start (2.5), active grill shutters (at the 0.6-gram effectiveness level modeled by EPA), active powertrain warm-up on both the engine and the transmission (3.0), thermal management technologies at the maximum 3.0-gram cap for that category, and LED external lights (1.0). This would leave unimplemented at least 4.0 grams CO_2 per mile in other available passenger car off-cycle credits for other technologies.

While passenger cars could thus be somewhat constrained by the off-cycle credit cap, the credit cap constraints are much more severe for trucks, since the truck credits are bigger. A truck with only stop-start (4.4) and active aerodynamic features (1.0) would already be at a 5.4 grams CO_2 per mile credit level. Adding thermal management technologies at the maximum cap for that category (4.3) brings the truck credit total to 9.7 grams – just short of the 10.0-gram cap. If the truck had all the technologies from the previous passenger car scenario, adding active powertrain warm-up (6.4) and LED lights (1.0), the truck would be at a credit level of 17.1 grams CO_2 per mile, and (as in the passenger car scenario) there would still be remaining unimplemented technologies worth at least another 4.0 grams.

These hypothetical scenarios show that the off-cycle credit caps could easily become binding for a manufacturer that tried to implement a comprehensive program to apply these technologies across its fleet and earn the associated credits, especially if that manufacturer had a significant portion of trucks in its fleet. Because of the critical importance of off-cycle credits amidst the challenge of the 2025 standards, these types of comprehensive programs to pursue these credits are emerging, as the industry has demonstrated by earning credits faster than initially assumed in the EPA analysis. Going forward, the 10.0 gram CO_2 per mile cap on total off-cycle credits from the pre-approved list is likely to become counterproductive, as it limits the incentive for manufacturers to implement off-cycle emissions reduction technologies to the maximum possible extent. This 10.0-gram cap serves no beneficial purpose and is even likely to become counterproductive, and should therefore be eliminated.

Similarly, the caps on thermal management technology credits can be expected to become a binding constraint that will limit the incentive to implement these technologies, possibly causing manufacturers to stop short of the maximum possible usage of these beneficial technologies. Once again, some hypothetical scenarios can provide perspective on how easily a manufacturer could become constrained by the thermal management caps. For passenger cars, the maximum thermal management glass credit is 2.9 grams CO_2 per mile, which is almost equal to the 3.0 grams cap for all thermal management technology credits for passenger cars. So the credits available in the thermal management category could conceivably be nearly exhausted solely by a comprehensive program at a manufacturer to adopt solar management glass at the maximum credited level. This would leave unimplemented up to 3.4 grams in potential credits from other thermal management technologies such as cooled seats (1.0), solar reflective paint (0.4), and active cabin ventilation (2.1).

A similar situation exists for trucks, where the maximum allowed credit for solar management glass (3.9) almost reaches the total cap of 4.3 grams allowed for all thermal management technologies. A comprehensive program by a manufacturer to implement the maximum credited levels of solar management glass technology would leave unimplemented up to 4.2 grams in potential credit from other thermal management technologies such as cooled seats (1.3), solar reflective paint (0.5), and active cabin ventilation (2.8). Alternatively, to the extent a manufacturer chose to implement cooled seats, solar reflective paints, and cabin ventilation, the manufacturer would be constrained by the cap from implementing maximum levels of solar management glass technology.

As with the 10.0-gram cap on total off-cycle credits from the pre-approved list, the caps on thermal management technology off-cycle credits are likely to become counterproductive as they limit the implementation of beneficial emission reduction technologies. These caps should ideally be eliminated. Alternatively, if the thermal management off-cycle credit caps are not eliminated, they could be made less constraining if they were administered as fleet average credit caps, rather than per-vehicle caps. The detail of whether these should be fleet average or per-vehicle caps was not specified in the regulation, and EPA has chosen to adopt the more restrictive interpretation that these thermal management credit caps should apply to each individual vehicle. This interpretation has proven to be particularly troublesome to implement since the database and accounting systems for compliance reporting have not typically been constructed to check whether credit caps have been reached on each individual vehicle. Instead, these systems are typically constructed to compile fleet totals and fleet averages for each type of technology feature, and these totals can be compared relatively easily to a fleet average cap. In contrast, checking the cap on each vehicle requires going back to each vehicle VIN to check the individual equipment level for each vehicle, which is a laborious task that can be expected to become increasingly difficult as rising technology implementation brings more vehicles to the cap.

The EPA interpretation of how to implement thermal management credit caps should be revised to partially alleviate the counterproductive constraints from the caps by implementing the cap on a fleet average basis, instead of implementing the cap on each vehicle.

Additional Off-Cycle Technologies

While the pre-approved off-cycle credit list created for 2014 has been a success, other aspects of the off-cycle credit provisions have been underperforming. As described in the Draft TAR, only a few special applications for off-cycle credit have been approved under the other two pathways for earning credit. These two pathways are using either five-cycle testing or using an alternative methodology that is posted for public comments. The industry needs the off-cycle credit program to function effectively to fulfill the significant role that will be needed for generating large quantities of credits from this type of emission reduction. This means that off-cycle credit applications should be processed more quickly and with fewer barriers. Credit applications are requiring extensive time and data, testing and other demonstration requirements are sometimes excessive.

In principle, procedures should be simplified and standardized, and data (where appropriate) from one manufacturer's application for a technology should be used generically for similar applications from other manufacturers relative to the same technology. This will not only reduce barriers to implementation, it will help ensure a level playing field among manufacturers and give manufacturers and suppliers some assurances when deciding to invest in these technologies.

One example would be the variable CS valve technology, previously discussed, that received off-cycle credit in an application under pathway three by General Motors. The benefits of this technology would not be expected to vary significantly due to vehicle-specific controls or other vehicle-specific attributes, and there should not be a great need for additional testing to confirm the benefits for additional applications of the technology by other manufacturers, especially since the credit was approved for General Motors at a conservative amount under the "worst case" test conditions of a using small displacement compressor (at the low end of the range of sizes used by General Motors). Yet no additional credits have been approved for the use of this technology by other manufacturers in the year since the General Motors credits were approved by EPA, which occurred on September 1, 2015.

EPA has adopted a position that other manufacturers must gather test data to generally the same extent performed by General Motors in order for EPA to review other applications for the same technology on a case-by-case basis. In practice, this testing requirement has proven to be a prohibitive barrier to the spreading of off-cycle credit incentives for other companies to accelerate adoption of this beneficial technology. There should be some way to establish simplified procedures for credit approvals which avoid this type of outcome. For example, in this case, additional approvals might be based on some simplified usage of supplier bench test data for additional compressors that use the variable CS valve technology. Ideally, EPA could provide language in the MTE process that once an off-cycle technology credit is approved for the first manufacturer, EPA allow for the use of the credit by all manufacturers for the same or similar technologies through a simple guidance letter.

To accelerate processing of off-cycle credit requests, the automakers have petitioned that EPA and NHTSA consider providing for a default acceptance of petitions for off-cycle credits, provided that all required information has been provided.[361] Limited Agency resources have delayed the processing of these petitions, and the delay impedes manufacturers' ability to plan for compliance or make investment decisions. Streamlining the process in this manner has therefore been suggested.

Many additional off-cycle technologies have been recommended by the Alliance in past rulemaking processes for inclusion on the list of pre-approved credits. Some of these include: high efficiency alternators, axle heaters, eco buttons, air conditioner compressors with the variable crankcase suction valve, transmission bypass valves, automatic tire inflation, adaptive cruise control and other safety and driver assist technologies, such as navigation systems and

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[361] "Petition for Direct Final Rule with Regard to Various Aspects of the CAFE and GHG Program," Submitted to EPA and NHTSA, June 20, 2016.

autonomous driving technologies, electrified accessories, and pickup tonneau covers. As a part of the midterm review process, EPA should revisit the examination of these technologies for potential inclusion onto the list of pre-approved off-cycle credits (or generalized pre-approval through guidance letter), and increase the cap accordingly to reflect the increased potential for fuel consumption reduction. At the same time, EPA should revisit certain technologies to increase their credit values, such as stop-start, in view of the considerable information on higher real-world idle times that has been gained since the original default stop-start credit was calculated for the pre-approved credit list.

Looking farther into the future, EPA and NHTSA should begin the technical studies to support the next generations of innovative fuel savings technologies, and develop off-cycle credit frameworks to accelerate their implementation. For example, the Agencies should study the credit potential for innovative safety and congestion mitigation technologies, such as improved vehicle to vehicle (V2V) and vehicle to grid (V2G) communications, car-sharing services, and car hailing services (e.g. Lyft).

The program could be further stimulated through the use of additional credits for the achievement of especially ambitious goals. For example, additional credits could be established for achievement of accelerated technology roll-out goals, technology fleet penetration goals or other objectives (e.g. credit for 85% implementation of a technology such as start-stop on an OEM fleet, credits for early introduction of safety/congestion mitigation technologies). Additional credits could also be established for early phase-out or other limits on features with adverse off-cycle fuel economy, emissions, or other impacts.

Eco-Innovations

A big breakthrough in international harmonization of regulations could be achieved if eco innovation GHG technologies approved by the E.U. were automatically adopted into the EPA system. This would essentially be an additional list of pre-defined and pre-approved off-cycle credits. The eco innovations regulatory provisions and the associated technologies are a feature of the E.U. light-duty greenhouse gas regulatory program, and generally correspond to the off-cycle provisions of the U.S. regulation. Credit applications for eco innovation technologies are thoroughly reviewed by the European Union's Joint Research Center, which provides the technical expertise to grant appropriate credits. The E.U. rules for eco innovation credits are very restrictive, and the review process is arduous, and as a result the volume of eco innovation credits granted has been low. However, this difficult review and approval process means that the eco innovation credits which are approved can be relied on as incentivizing technologies which produce thoroughly verified real-world GHG reductions.

Thus far, the E.U. has granted eco innovation credits for efficient alternators, engine compartment encapsulation, enthalpy storage tanks, efficient lighting (already on the EPA list), solar panels (already on the EPA list), engine-off coasting technology, and navigation-based battery preconditioning. The credits are generally based on an eco-innovation template that provides test procedures and a generic calculation of the credit for all manufacturers that adopt the technology.[362]

Advanced Technology Incentives for Large Pickups

The Draft TAR recounts the full size pick-up truck incentives as provided in the 2012 FRM, but does not evaluate the provision's effectiveness in promoting the adoption of "game changing" technologies as intended.[363] We believe that for the provisions to provide a meaningful incentive that meet the Agencies objectives, the eligibility criteria needs to be less restrictive and the scope expanded beyond full size pick-up trucks.

The 2012 FRM provides incentives for full size pick-up trucks with hybrid systems, and other technologies that significantly reduce CO_2 emissions and fuel consumption. The Agencies focused the flexibility on full-size pickup trucks because of the challenge the MY2017–2025 standards will present for large vehicles, including full-size pickup trucks, that are often used for commercial purposes and must maintain utility, towing and payload capability. The Agencies' stated intent of these provisions is to incentivize the penetration of ''game changing'' technologies for large pickup trucks into the marketplace. The incentives were also intended to create an opportunity in the early years of the MY2017-2025 program to begin penetration of advanced technologies into large pickup trucks, which in turn could enhance the chance for achieving the more stringent later year standards for those vehicles.[364]

The challenges of meeting the MY2022-2025 standards and in applying advanced technologies such as hybridization extend beyond just full-size pickup trucks

As discussed in the summary to these comments, it is clear that hybrid technology in particular does not just hold game changing potential for full size pick-up trucks; it will be a necessity across the fleet in order to attain compliance with MY2022-2025 standards, and will be needed at greater penetration rates than the Agencies have projected.

The challenge will be in achieving hybrid technology deployment in the volumes needed for compliance considering the technology's associated cost premiums increase exponentially with increased vehicle weight and utility requirements as can be seen in Figure G-1 below.

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[362] http://ec.europa.eu/clima/policies/transport/vehicles/cars/documentation_en.htm.
[363] 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, (EPA-420-D-16-900, July 2016) at p. 11-6 et seq.
[364] *Id.* at 11-6.

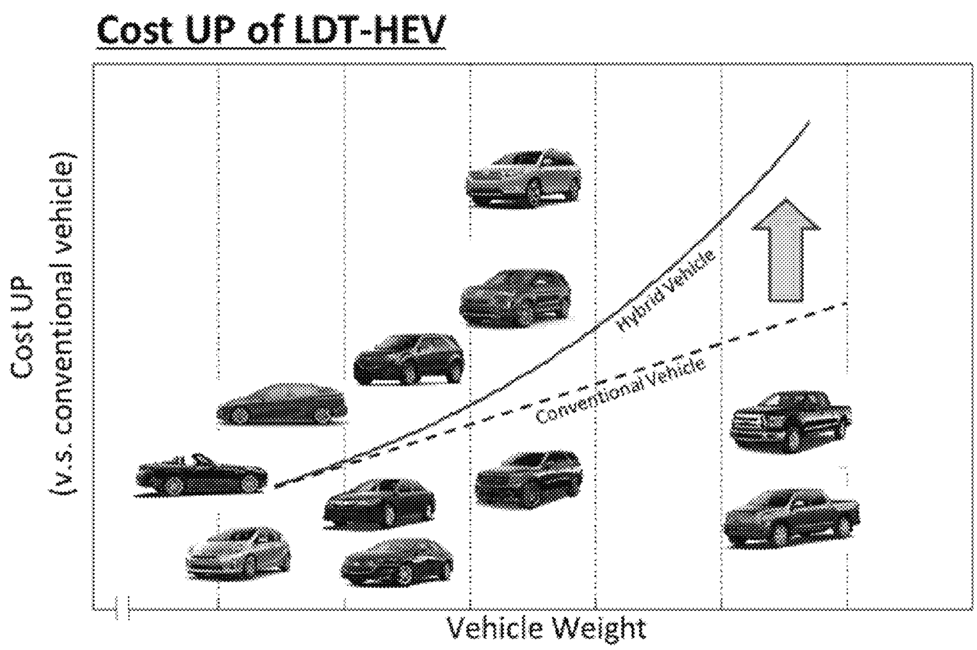

Figure G-1: Generic Cost Diagram Demonstrating Exponential Increase of Strong Hybrid Technology With Vehicle Weight

The Agencies noted in the 2012 FRM that:

> Although there may not be inherent reasons for a lack of hybrid technology migration to large trucks, it is clear that this migration has nevertheless been slow to materialize for practical/economic reasons, including in-use duty cycles and customer expectations. These issues still need to be addressed by the designers of large pickups to successfully introduce these technologies in these trucks, and we believe that assistance in the form of a focused, well-defined incentive program is warranted.[365]

We believe system capability and cost present the primary hurdle to the migration of hybrids to full-size pickup trucks, and contend that the technology capability, cost, and customer acceptance challenges are not unique to that segment of the light-duty truck fleet. In fact, more full-size pickup trucks have employed hybrid technology than full-size SUVs or minivans. The great disparity between passenger car and light-duty truck hybrids is demonstrated in Figure G-2 below.

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[365] 77 Fed. Reg. 62739 (Oct. 15, 2012).

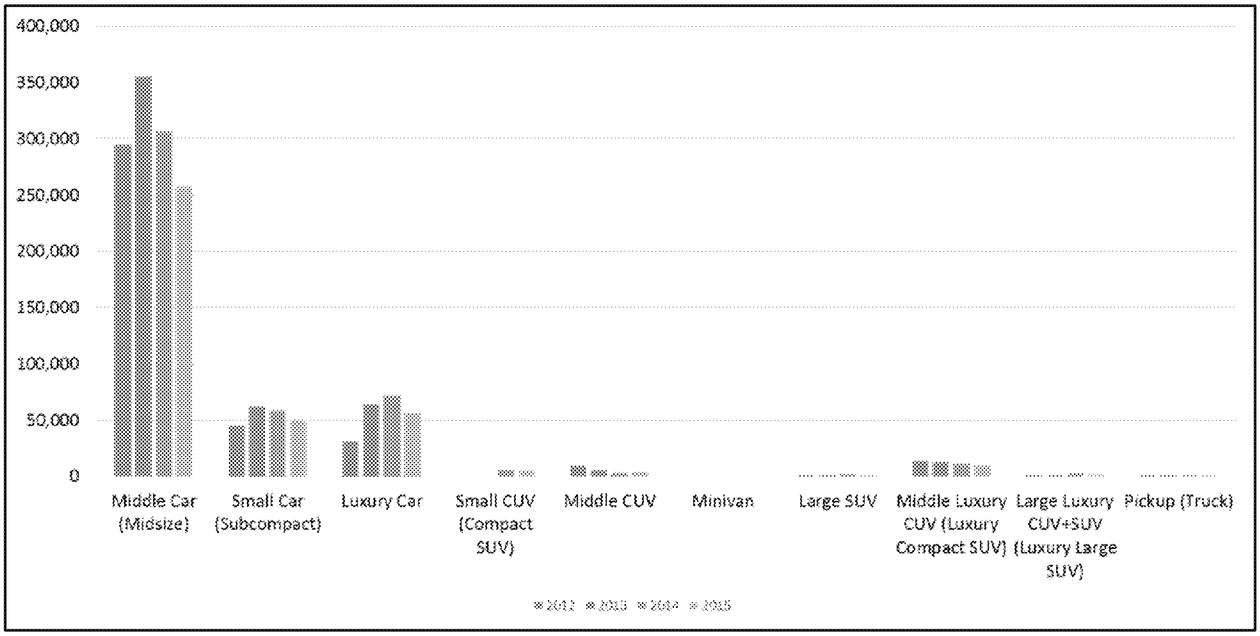

Figure G-2: Hybrid Sales by Vehicle Segment[366]

The utility challenge for many SUVs and smaller pickup trucks is similar to that for full-size pickups. The Agencies note in the final rule that some non-pickup light-duty trucks do have substantial towing capacity, but go on to say they not believe an incentive was warranted because most are not used as towing vehicles, in contrast to full-size pickup trucks that often serve as work vehicles.[367] We contend the frequency of towing or work operation is irrelevant in determining hybrid system design requirements. System design and the resulting costs are determined by the worst case or most severe conditions anticipated. If only 10% of SUVs or other non-pickup LDTs are used for towing, the hybrid system for every vehicle in a given model must still be designed for that 10% usage condition.

In restricting the provision to full-size pickup trucks in the final rule, the Agencies contend that smaller footprint trucks fall on the lower part of the truck curve, which have a higher rate of improvement (in stringency) than the larger trucks, thus making them more comparable to cars in terms of technology access and effectiveness[368] (which also do not have access to the incentives discussed here). While these smaller footprint trucks may not entail the duty-cycle requirements associated with full-size pickups and larger non-pickup light-duty trucks, they all offer greater utility than a passenger car and the stringency of the applicable standards for these smaller footprint trucks create their own significant challenges even for hybrid technology. Furthermore, many of the conventional powertrain efficiency and vehicle tractive energy improvements such

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[366] Ward's Automotive
[367] 77 Fed. Reg. 62739 (Oct. 15, 2012).
[368] *Id.*

as engine downsizing, turbocharging, and mass reduction actually provide a comparatively greater benefit for the larger heavier truck segments and are hence more cost effective for the larger pick-up trucks.

Promoting hybrid technology in the smaller light-duty truck segments, precisely because of the less severe utility requirements, offers a more cost-effective proving ground that can provide valuable experience about hybrid truck requirements and customer preference that is transferrable to the design process for the full size pickup and larger non light-duty truck segments. Building the customer base for hybrids in the lighter truck segments can help promote the eventual adoption/acceptance in the more challenging larger truck segments. That said, cost does remain a hurdle for acceptance of hybrids in the smaller, lighter truck segments. All of this warrants some level of incentive for hybrids beyond the large pickup truck segment.

The penetration rate-based eligibility requirements for the advanced technology pickup truck incentives are too restrictive

It is unlikely the advanced technology full-size pickup truck incentive provisions, as currently designed, will achieve their stated objectives. The 2017 model year has started and there is no indication that manufacturers will pursue these incentives. One likely reason is because the penetration rate eligibility criteria is too restrictive and ignores the longstanding industrywide practice of carefully introducing new technology into the market, especially those that entail cost premiums, performance challenges and possible customer acceptance issues.[369]

Technology uptake typically follows an S-curve pattern. Deployment after introduction starts at a slow pace aimed at a niche market where acceptance is gauged and necessary improvements are learned and implemented. Once manufacturer and customer confidence is gained, rapid growth occurs as deployment is scaled up toward mainstream volumes. Eventually penetration rate increases tail off as the technology saturates the market to the degree desired by customers.

Figures G-3 and G-4 show that this gradual growth often takes a decade or more to reach a percent 10% market share (the required eligibility threshold for the strong hybrid advanced technology full-size pickup truck incentive). The technologies in Figures 7-3 and 7-4 are significantly less expensive than the application of strong hybridization to the light-duty truck fleet. All of this makes the expectation of 10% sales share for strong hybrids at the time of introduction within any given model unrealistic and counterproductive to the goal of increasing hybrid penetration in the truck market. The total hybrid share in the U.S. market has never been

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[369] We note that the addition of hybrid technologies entails challenges to meeting customer expectations. For example, large batteries can add mass, requiring additional engineering and cost to maintain expected payload and towing capabilities. Additionally, off-road applications may require additional sealing to prevent dirt or water intrusion.

higher than 4%. For models that contain both a hybrid and non-hybrid variant, as seen in Figure G-5, the average hybrid share as of May 31, 2016 is 6.2% for 2016 MY light-duty trucks.[370]

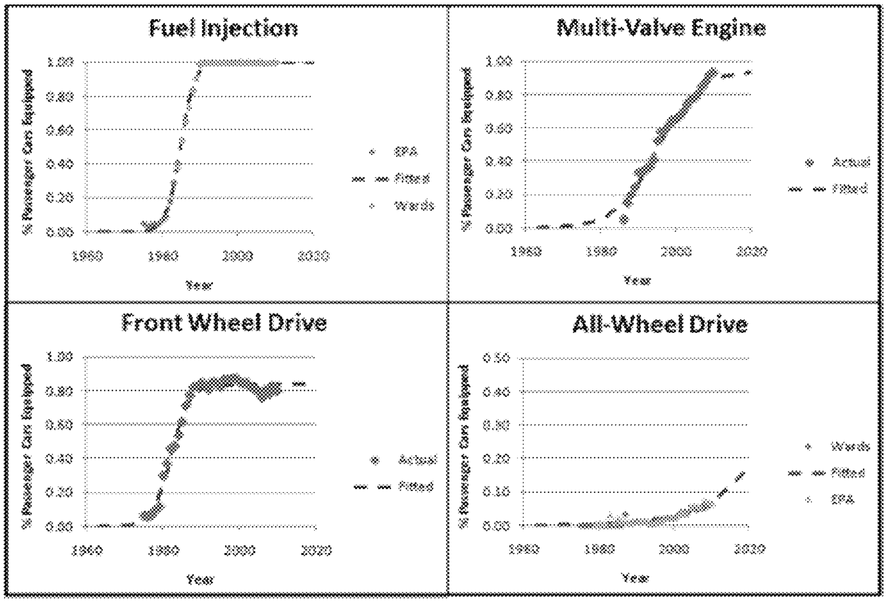

Figure G-3: Technology Deployment Rates for Fuel Injection, Multi-Valve Engine, Front Wheel Drive, and All-Wheel Drive[371]

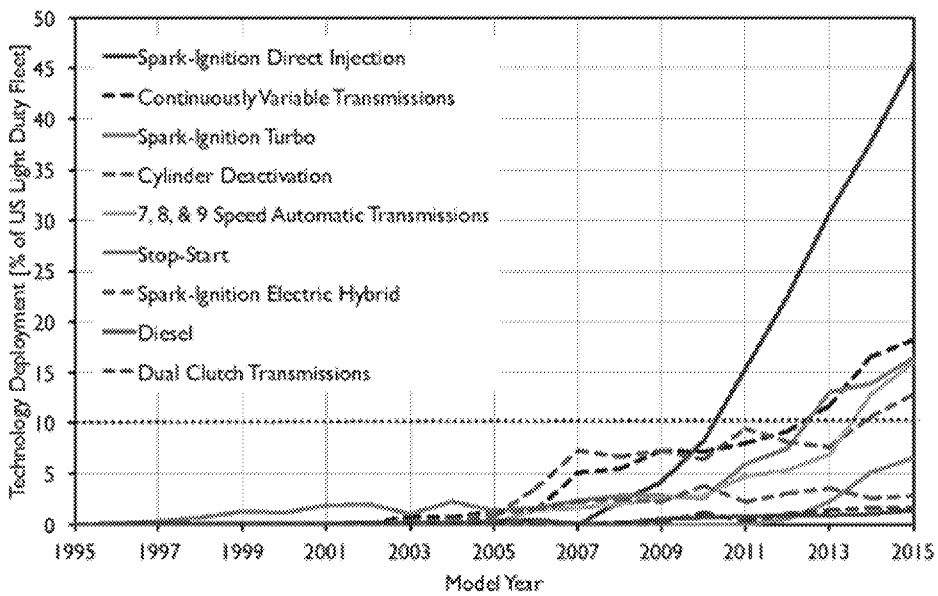

Figure G-4: Light-Duty Truck Hybrid Sales Share[372]

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[370] Polk

[371] Stephen M. Zoepf. "Automotive Features: Mass Impact and Deployment Characterization. Massachusetts Institute of Technology. June 2011.

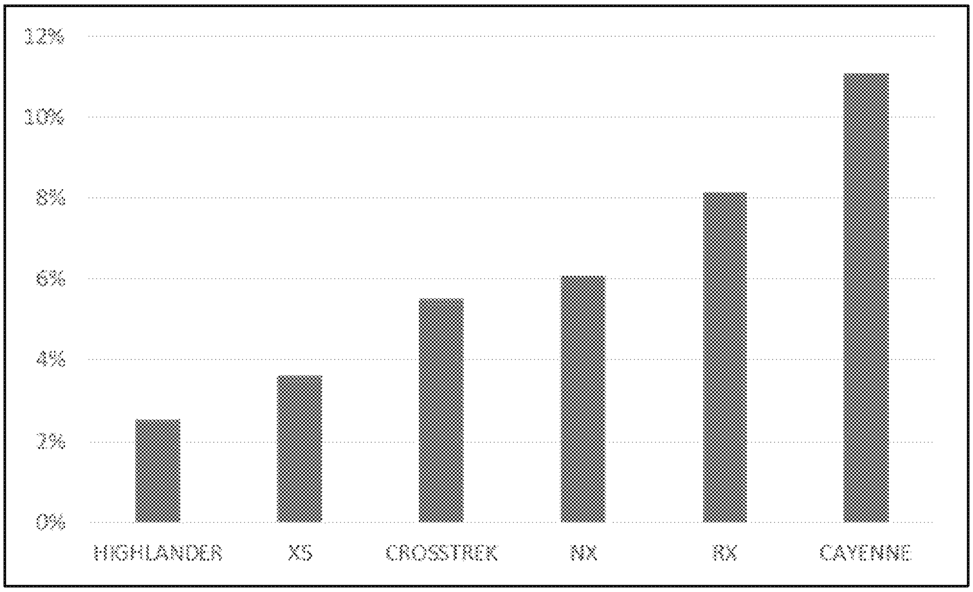

Figure G-5: Light-Duty Truck Hybrid Sales Share[373]

The current eligibility threshold is inconsistent with the Agencies' stated goal of fostering production of these technologies at levels that will help achieve economies of scale, promote greater fuel savings overall, and make these technologies more cost effective and available in the MY2022-2025. Therefore, the eligibility threshold should be eliminated. It would be more appropriate to consider a maximum threshold above which the technology's stability in the market would be considered to no longer warranting an incentive.

Hybrids Offer Transition to Greater Levels of Electrification

As stated previously, the Alliance contends that more hybrids or other forms of electrification will be needed to comply with the MY2022-2025 standards than assumed in the Draft TAR. The Alliance also recognizes that the stringency of CAFE and GHG standards will likely increase beyond MY2025 as the need to address climate change and energy security will continue. While conventional gasoline powertrains will continue to play an important role beyond MY2025, post-MY2021 powertrain investments are expected to increasingly involve hybrids and other forms of electrification as a necessity. Hybrids can also aid on the transition to PHEVs, EVs, and FCs.

In the Draft TAR, EPA explains that CNG vehicles are not viewed as a game changing technology from a GHG tailpipe emissions perspective. Nonetheless, EPA included a multiplier

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[372] "MY 2015 Baseline Study." Novation Analytics. 2016. And "Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975-2015." U.S. Environmental Protection Agency. EPA-420-R-15-016. December 2015.
[373] Polk

incentive for dedicated and dual-fueled CNG vehicles because EPA considered investments in CNG technology and refueling infrastructure to be a valuable, indirect step towards hydrogen FCVs, which can be a game-changer in terms of GHG emissions. In this way, EPA believed that CNG could be a critical facilitator of a next-generation technology.[374] The same logic applies to hybrids as they can help build the industrial base required for electric vehicles which share common components (motors, power control systems, etc.) and production techniques as well as help socialize the market for greater levels of electrification. Even viewed as a bridge technology, conventional hybrids can provide game changing GHG reductions and should be considered for at least some level of technology incentive in light-duty trucks beyond just full-size pickup trucks.

Electric Vehicle Upstream Emissions

With regard to upstream emissions, the Alliance recommends that EPA permanently allow automobile manufacturers in their compliance accounting for this regulation to attribute 0 grams of CO_2 per mile for the upstream emissions associated with generating electricity used as a transportation fuel. This is a critically important revision to make at this time, as manufacturers anticipate that PEVs and fuel cell vehicles (FCVs) will need to play a much larger role in meeting standards through 2025 than forecast in the Draft TAR.

The MTE was designated at the time the 2017-2025 regulation was issued as an appropriate point to review the inclusion after 2021 of upstream GHG emissions from electric power generation in the accounting for emissions of plug-in electric vehicles, as well as the upstream emissions for fuel production for fuel cell vehicles.[375] As was noted in the 2012 FRM, "traditionally the emissions of the vehicle itself are all that EPA takes into account for purposes of compliance with standards set under Clean Air Act section 202(a)."[376]

Despite EPA's tradition of not including upstream emissions in measuring compliance with vehicle standards, EPA attempted to achieve a complicated balancing of considerations in the 2017-2025 rule for PEVs and FCVs. On the one hand, EPA wished to extend incentives to encourage the commercialization of PEVS and FCVs, since these technologies were judged by EPA to "have the potential to achieve game-changing GHG emissions reductions in the future."[377] Toward this end, the 2017-2025 regulation created a schedule of multiplier credits for

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[374] 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, (EPA-420-D-16-900, July 2016) at 11-6, 11-7.
[375] 77 Fed. Reg. 62623, 62820 (Oct. 15, 2012).
[376] *Id.* at 62816.
[377] *Id.* at 62813.

PEVs and FCVs through 2021. Also through 2021, PEVs and FCVs could include 0 grams CO_2 per mile in their compliance accounting for upstream emissions incurred to create and distribute their fuels. However, after 2021, EPA created volume thresholds that would trigger a switch in PEV and FCV compliance accounting, whereby PEVs and FCVs would move from a framework of favorable incentives into an unusually disfavored status, losing their multipliers while also becoming the only vehicles that would be hit with an unfavorable upstream emissions factor to account for the additional emissions used to create and distribute their fuels, compared to gasoline. This disfavored status would be applied consistently for all manufacturers by 2026, regardless of whether the volume thresholds had been reached.[378] There is an obvious inconsistency in this switch after 2021, changing from incentivizing electric vehicles and fuel cell vehicles to encourage their commercialization, and instead dis-incentivizing them through the revised upstream emissions accounting treatment. It should be noted that in a rare departure from maintaining strict harmonization, Canada has revisited EV, FCV, and PHEV multipliers; increasing and extending them to further incentivize their introduction into the market.

In contrast, EPA declined to create multipliers or other adjustments to favor LPG or advanced diesels[379] or biofuels.[380] This was based on EPA's judgment that these technologies would not be fundamentally "transformative" with respect to vehicle GHG emissions. Instead, EPA applied their traditional approach of regulating the tailpipe emissions associated with these fuels, with no adjustment for their upstream impacts. This was a major setback for biofuels, where the upstream GHG impacts are generally considered to be significantly favorable, such as estimated under the California Low Carbon Fuels Standard.[381] This creates yet another inconsistency under the current EPA regulation, since no credit is given for the favorable upstream impacts of biofuels (or diesel, or any other fuel which could claim lower upstream emissions than gasoline), yet electric vehicles and fuel cell vehicles are penalized for the unfavorable upstream emissions attributed to their fuels.

EPA offered the justification that upstream GHG emissions for transportation fuels production and distribution was not directly and comprehensively regulated, and should therefore have been regulated indirectly by way of the vehicle GHG standards:

> At the time of the final rule, however, there was no such comprehensive program addressing upstream emissions of GHGs...Therefore, EPA placed limits on the use of 0 g/mile for MY2022-2025 vehicles and the use of 0 g/mile is currently not allowed after MY2025. EPA included per-company vehicle production caps for

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[378] *Id.* at 63181.
[379] *Id.* at 62822.
[380] *Id.* at 62824.
[381] "Low Carbon Fuel Standard." State of California Air Resources Board. Accessed September 26, 2016. https://www.arb.ca.gov/fuels/lcfs/lcfs.htm.

> use of 0 g/mile in MYs 2022–2025, and 0 g/mile cannot be used for production that exceeds these caps….Once the production cap is met, the manufacturer must include net upstream emissions associated with electricity generation on a g/mile basis in their compliance calculations.[382]

However, EPA has subsequently acknowledged that conditions have changed, and that the primary basis for including upstream emissions for PEVs and FCVs after 2021 has now been removed:

> EPA recognized that the mid-term evaluation would provide an opportunity to review the status of advanced vehicle technology commercialization, the status of upstream GHG emissions control programs, and other relevant factors. At the time of the MY2017-2025 final rule, part of the rationale for including upstream emissions associated with electricity production, for production volumes in excess of the per-company production volume caps, was because these upstream GHG emissions values are generally higher than the upstream GHG emissions values associated with gasoline vehicles, and because there was then no federal program in place to reduce GHG emissions from electric power plants….Since the MY2017-2025 final rule, EPA has adopted GHG controls for electricity generation. On August 3, 2015, EPA issued final GHG emissions regulations addressing both existing (referred to as the Clean Power Plan) and new electricity generating units. These rules are expected to markedly decrease GHG emissions associated with future electricity generation.[383]

The Clean Power Plan, although currently tayed by the U.S. Supreme Court, is a comprehensive EPA program that aims to reduce GHG emissions from electricity generation facilities by 32% in 2030, compared to 2005 levels. It creates a complex framework for states to create their own statewide implementation plans to meet the wide range of individual emission reduction targets assigned to them by EPA. While the aggregate emissions reductions of this new program should be large and unprecedented, there are many unresolved issues and uncertainties, and the changes in the generation sector can be expected to be much greater than experienced or contemplated in the past. In view of these uncertainties and the dramatic changes expected in the electricity generation sector, reliable upstream emissions factors for the next ten years cannot be created at this time to attribute to electric vehicles under the light-duty vehicle GHG regulation. However, if they could be reliably estimated, they would be expected to be falling rapidly due to the new

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[382] 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, (EPA-420-D-16-900, July 2016) at 11-7.
[383] *Id.* at 11-7.

Clean Power Plan, such that the additional upstream emissions premium from this fuel pathway compared to gasoline could be vanishing, or reaching very low levels.

In summary, the creation of the Clean Power Plan to comprehensively regulate and significantly reduce GHG emissions from the electricity generation sector has removed the primary rational for EPA to include upstream emissions factors in its GHG compliance framework for electric vehicles. Removing these PEV upstream emissions factors would return EPA to its traditional framework for regulation of vehicle emissions, which included only emissions from the actual vehicle. It would also make regulation of electricity as a transportation fuel consistent with regulation of other fuels (such as biofuels), and would remove a regulatory disincentive to the commercialization of electric vehicles. Finally, removing the upstream emissions factors for electric vehicles allows EPA to avoid the immense difficulty of fairly estimating future emissions factors amidst anticipated rapidly changing conditions in the electricity generation sector. Therefore, the Alliance recommends that EPA permanently allow automobile manufacturers, in their compliance accounting for this regulation, to attribute 0 grams of CO_2 per mile for the upstream emissions associated with generating electricity used as a transportation fuel. This is a critically important revision to make at this time, as manufacturers anticipate that PEVs and FCVs will need to play a much larger role in meeting standards through 2025 than forecast in the Draft TAR.

NHTSA and EPA Harmonization

On June 20, 2016, the Alliance and Global Automakers petitioned EPA and NHTSA to make several regulatory changes to better harmonize their respective regulations for GHG and FE. The issues raised in this petition are relevant for the MTE and the Draft TAR because of many interactions with the assessments of this review.[384]

For example, it was requested in the petition that EPA and NHTSA calculate the fuel economy for a manufacturer's fleets for MY2010-2016, to account for off-cycle technologies at the same levels and in the same way as EPA accounts for those technologies in the GHG program. This would be consistent with the procedures for both NHTSA and EPA in 2017-2025, and doing so would not erode the overall benefits of the CAFE standards or the ONP.

Similarly, the Alliance and Global Automakers requested the Agencies calculate the fuel economy for a manufacturer's fleets for MY2010-2016 to account for air conditioning efficiencies at the same levels and the same ways as EPA is accounting for those efficiencies in the GHG program. The Alliance and Global Automakers provided an approach that would grant such credits while also accounting for the differences in the stringency of the GHG and CAFE

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[384] Letter from C. Nevers to Mark Rosekind, PhD and Gina McCarthy re: 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). Attached as Attachment 10.

standards. This approach was based on originally not having included these credits in the CAFE standards, such that credits would only be granted to the extent that manufacturers implemented MAC efficiency technologies faster than EPA assumed when it incorporated these technologies in setting the stringency of its standards.

The Alliance and Global Automakers also requested that NHTSA apply the adjustment factor, beginning in Model Year 2011, when credits are carried forward or carried back within a compliance category, as well as when they are traded and transferred. The adjustment factor in 49 C.F.R. Part 536 was established by NHTSA in response to the Congressional mandate to ensure that when creating a program for trading credits between manufacturers, that overall oil savings remains the same. EPA has a different approach to ensuring the consistency of the benefits in the GHG program. The change requested would help to harmonize the two approaches since the adjustment factor equates the CAFE credit to a linear function similar to the way in which credits are applied in the GHG program.

The Alliance and Global Automakers also requested that NHTSA revise the definition of the term “transfer” in 40 CFR 536.3 to be consistent with language in the 2010 preamble of the proposed rulemaking for 2017-2025 GHG/CAFE standards. This revision would more closely align the NHTSA credit transfer program with that of the EPA GHG provisions as was the expressed intent of the 2010 preamble language.

Alliance and Global Automakers also requested that the Agencies allow manufacturers to manage their credit supply and use. While the manufacturer model year reports track certain credits separately, such as the off-cycle credits, and appear to allow manufacturers the ability to apply either those credits or over-compliance credits as they choose, in a recent publication EPA stated instead that technology credits must be applied before any over-compliance credits are applied. Rather than imposing a priority system on the application of credits, the Alliance and Global Automakers requested that the Agencies allow manufacturers to choose how to apply their available credits.

Appendix H: EPA and NHTSA Treatment of the California Zero Emission Vehicle Regulation

Including ZEV Program Cost

With respect to the ZEV regulations, Section 4.1.4.1 states,

> Because these ZEVs are already required by separate regulations in California and nine other states, these vehicles are built into the EPA reference fleet. This approach reasonably avoids attributing costs to the federal GHG program which necessarily occur due to another existing requirement and assures that those costs are not double counted.[385]

The Alliance agrees that costs should not be double counted, but costs should be counted at least once, particularly since the Draft TAR was developed by the Agency adopting the ZEV regulations (CARB) and the Agency granting a waiver for the ZEV regulations (EPA). Otherwise, the Draft TAR violates the basic tenets of cost-benefit analysis, counting the GHG reductions that result from the ZEV Program as part of the benefit of the federal GHG program, but ignoring the significant associated costs.

In a recent rulemaking, in which CARB was considering reducing the total number of ZEVs from intermediate volume manufacturers, CARB noted:

> The fleet average requirements ensure that air quality benefits do not suffer as a result of an automaker producing fewer ZEVs. Therefore, although the proposed amendments could lead to fewer ZEVs and TZEVs being delivered to California from 2018 to 2025, since the amendments do not modify the in-place fleet average emission standards, the air quality benefits of the ACC [Advanced Clean Car] Program as analyzed in 2011 in the ACC EA [Environmental Assessment] will still be realized.[386]

Of course, CARB is correct – emissions are controlled by very stringent fleet average requirements and the ZEV regulations have no impact on GHG emissions of new vehicles. To the extent that ZEVs are placed in service, they offset other higher emitting vehicles. For example, Tesla Motors produces only electric vehicles that receive GHG credits; according to SEC filings, Tesla Motors sold these GHG credits for almost $200 million.

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[385] 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, (EPA-420-D-16-900, July 2016) at 4-37.

[386] "Initial Statement of Reasons for Rulemaking; Proposed 2014 Amendments to the Zero Emission Vehicle Regulation. State of California Air Resources Board. 2014. 17.

Consequently, the Alliance finds itself in the situation where CARB rightly declares there are no benefits to the ZEV regulations, and the Agencies claim there are no costs while using the ZEV regulations to reduce the cost of the GHG regulation.

Rather than ignoring the costs and counting the benefits, the Agencies should calculate the baseline, reference, and control fleets with the ZEV technology packages available in OMEGA but assume no ZEV regulations are in place. This would determine the number of ZEVs required to meet the GHG regulations absent ZEV regulations. Then the baseline, reference, and control fleets could be recalculated with the ZEV regulations in place. The costs associated with the ZEV regulation can then be properly assigned.

Background

Over the past year, automakers have urged the Agencies to take ZEV Program costs into account during the MTE. EPA has done so, but in a way that violates the basic rules of cost-benefit analysis.

The ZEV Program began in 1990 with CARB's adoption of standards calling for each manufacturer doing business in California to sell 2% ZEVs in 1998, 5% in 2001, and 10% in 2003 within that state. Since 1990, CARB has amended the program several times to account for technical challenges, unexpected costs, and other issues. For example, in 1990 CARB originally estimated that a battery electric vehicle would cost about $1,350 more than a similar gasoline vehicle in 2000.[387] However, 21 years later, in their December 7, 2011 Initial Statement of Reasons (ISOR), CARB projected a battery electric vehicle would cost over $17,000 more than a similar gasoline vehicle in 2016.[388] Currently, the ZEV Program is based on manufacturers generating an increasing number of "ZEV credits." ZEV credits are earned by either selling ZEVs, or purchasing ZEV credits from another manufacturer that has sold excess ZEVs. In the previously mentioned 2011 ISOR, CARB projected that the most likely compliance scenario automakers would pursue would result in 15.4%ZEVs in 2025. Pursuant to §177 of the Clean Air Act, nine other states have adopted the ZEV program.

When calculating the costs of implementing the MY2022-25 GHG standards, EPA builds into its reference fleet--and thereby excludes from its own program the costs of the 280,300 fully electric, plug-in hybrid, and hydrogen fuel-cell electric vehicles that manufacturers are expected to produce in 2021 alone to comply with the ZEV Program. In doing so, EPA acknowledges that it is departing from its own prior cost-benefit accounting practices, but explains that the ZEV

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[387] "Initial statement of proposed rulemaking for low-emission vehicles and clean fuels." State of California, Air Resources Board. 1990. 63.

[388] "Initial Statement of Reasons, 2012 Proposed Amendments to the California Zero Emission Vehicle Program Regulations." State of California, Air Resources Board. December 7, 2011. 60.

Program was not in the baseline for the 2012 federal GHG rulemaking because the ZEV Program was under revision and because EPA had not yet acted on CARB's waiver request.[389]

Costs and Breadth of the ZEV Requirements Under the Combined Programs

In considering the ZEV Program and the federal GHG program, certain things are apparent. The first is that these programs place unprecedented additional costs on manufacturers and customers. Here are just a few facts illustrating the unprecedented breadth and costs of these programs:

1. Economists working for ARB estimate that the vehicles manufacturers must produce to meet the ZEV Program requirements will cost customers between $7,500 and $15,000 more in MY2025, as compared to today's average vehicle prices.[390]

2. They also estimate that, by MY2025, compliance with the ZEV Program in California alone will cost automobile manufacturers more than $6 billion annually.[391]

3. The Draft TAR shows BEV200 incremental cost in excess of $16,000 in MY2021, and $14,000 in MY2025. Likewise, the PHEV40 incremental costs exceed $10,000 for the MY2021 to MY2025 timeframe.

4. Collectively, the ZEV states now represent 30% of new light-duty vehicle sales.[392]

5. EPA's analysis in the Draft TAR shows that manufacturers will need to sell an additional 220,057 ZEVs to meet the MY2021 federal GHG standards; by MY2025, this rises to 419,308 vehicles.[393]

6. Finally, the costs above are likely conservative, since these costs are incremental to a gasoline vehicle; that is, they assume that the ZEV and the gasoline vehicle can be sold at the same price. To the extent the transaction price of a ZEV is lower than the comparable gasoline vehicle, the costs of the program rise further. Currently, because of substantial automaker, federal, state, and local incentives, the transaction price of ZEVs is far below

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[389] 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, (EPA-420-D-16-900, July 2016) at 4-37.
[390] "Initial Statement of Reasons, 2012 Proposed Amendments to the California Zero Emission Vehicle Program Regulations." State of California, Air Resources Board. December 7, 2011. 64.
[391] *Id.* at Table 5.6.
[392] 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, (EPA-420-D-16-900, July 2016) at 4-43.
[393] *Id.* at 4-38, 4-39, Tables 4.25, 4.26, 4.27, 4.28.

that of comparable gasoline vehicles–in fact, in some parts of California, customers are paid to take a 3-year lease for certain ZEV models. In most parts of California, ZEVs are available for well below $100 per month for a 3-year lease. Moreover, as noted in the Draft TAR, manufacturers will begin to exhaust the Federal Tax Incentive (up to $7,500) as early as 2017 or 2018, placing an additional burden on those manufacturers.

California's regulatory process only requires CARB to consider the costs incurred by California business and enterprises.[394] In fact, none of the manufacturers currently subject to the ZEV regulations are based in California.[395] Other states desiring the ZEV Program are required to adopt standards identical to California's, and therefore do not have the option of adjusting the program to reflect economic impacts in or outside of their own states. If EPA now fails to account for the ZEV Program costs, this would mean *there is no point at which state or federal regulators fully consider these costs.*

The ZEV and GHG Programs Are Interwoven

Although the ZEV Program began as a way to address criteria pollutants, the primary reason for CARB's post-2017 ramp-up of the ZEV Program is the state's desire to meet its future GHG reduction goals (40% below 1990 levels by 2030 and 80% below 1990 levels by 2050).[396] This means that both the ZEV Program and the federal GHG requirements are now designed to address the same issue.

In a recent review of the CAFE, GHG and ZEV programs, researchers at Indiana University concluded:

> [T]the potential interactions between the federal and ZEV programs need to be analyzed because the presence of the ZEV program can have major implications for manufacturer compliance strategies, federal credit-trading markets, and attainment of environmental benefits.[397]

Cost-Related Issues That Need to Be Revisited

Use of Credits

Compliance costs with the ZEV regulation should assume that each manufacturer fully complies with the regulations. Purchasing ZEV credits can provide flexibility or cover short-term deficits.

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[394] California Government Code Sections 11346.3 and 11346.5.
[395] "Initial Statement of Reasons, 2012 Proposed Amendments to the California Zero Emission Vehicle Program Regulations." State of California, Air Resources Board. December 7, 2011. 55.
[396] "California's ZEV Regulation for 2018 and Subsequent Model Years." State of California Air Resources Board. Accessed September 26, 2016. http://www.arb.ca.gov/msprog/zevprog/zevtutorial/zev_tutorial_webcast.pdf.
[397] 243. Carley et al, "Rethinking Auto Fuel Economy Policy: Technical and Policy Suggestions for the 2016-17 Midterm Reviews," Phase 1 Report, 4, (Feb. 2016).

However, an automaker adopting ZEV credit purchases as a long-term compliance strategy will quickly find itself funding competitors' technology advances while falling further behind in technology development. Also, as the Agencies have predicted that all manufacturers will need to produce zero emission products to meet the MY2025 standards,[398] it is likely automakers will attempt to comply with regulations by developing technology and vehicles.

Inconsistent Estimates of ZEV Vehicle Needs

Another troubling aspect of EPA's analysis is the lack of clarity about the ZEV volume required to meet the ZEV regulations and the volume required to meet the GHG regulations. In Section 12.1.1.3.2, the Draft TAR states, "[t]herefore, some of the EV and PHEV penetration in the following tables is ZEV program-related (2.6% of the combined fleet), some is in EPA's purchased fleet projections (1.2%of the combined fleet), and some is generated by OMEGA to reach compliance (an additional 0.5% of the combined fleet for a total of 4.3%in the AEO2015 reference fuel price and ICM case)." Presumably, "ZEV program-related" refers to ZEVs that are required only because of the ZEV regulations. However, the Agencies should clarify what is meant by "EPA's purchased fleet projections" as distinguished from "ZEVs required by OMEGA to reach compliance."

Program Changeability

Building the ZEV Program vehicles into the baseline and reference fleets ignores potential changes in the ZEV Program requirements and the fluidity of California's regulatory process. As adopted by CARB in 1990, the original ZEV Program set a deadline of 2003 for manufacturers to meet a 10% ZEV sales requirement.[399] Since 1990, however, CARB has made five major changes to the regulations to better reflect technology, costs, and market conditions.[400] CARB's regulatory process allows for major program changes to be implemented much more quickly than EPA's. Any future adjustments, however, could have national implications for future manufacturer compliance planning. Recently, for instance, CARB's Board asked its staff to consider what program revisions would be needed to assure that 1.5 million ZEVs are sold in California by 2025.[401]

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[398] 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, (EPA-420-D-16-900, July 2016) at 12-20, Tables 12.21 and 12.22.
[399] Zero-Emission Vehicle Legal and Regulatory Activities and Background. State of California Air Resources Board. Accessed September 26, 2016. https://www.arb.ca.gov/msprog/zevprog/zevregs/zevregs.htm.
[400] *Id.*
[401] "Meeting; State of California Air Resources Board." July 21, 2016. Board Member Gioia p. 196, lines 8-13; Board Member Sherriffs p. 197, lines 16-20. Accessed September 26, 2016. https://www.arb.ca.gov/board/mt/2016/mt072116.pdf.

Recommendations

Now that EPA has made the ZEV Program mandates a key part of the ONP, the cost and feasibility of this separate program must be considered as a part of the MTE.

The Agencies should also develop and present costs based on different compliance paths, assuming the ZEV regulations do not exist and in full compliance with the ZEV regulations. The Agencies should include a detailed analysis of the cost of the ZEV Program as it stands today, and if it changes, as a part of the MTE for public comment. Moreover, the Agencies should consider the current transaction prices, likely changes in those transaction prices based on customer acceptance of the technology, and how these changes impact the costs of the regulations.

Going forward, ZEV Program changes must occur in conjunction with the proposed determination and NPRM, as the Agencies have now (appropriately) tied these two programs together.

Appendix I: Alternative Fuel Infrastructure

EPA assumes ZEV mandate levels of electrification within its modeling of the 2021 reference and control fleets. In addition, the Alliance believes a much greater degree of advanced technology is likely required for compliance with the MY2022-2025 standards than modeled by the Agencies in the Draft TAR, at least a portion of which may require additional alternative fuel infrastructure. Therefore, consideration of the status of alternative fuel infrastructure systems is warranted. The Agencies have provided their assessment in Chapter 9 of the Draft TAR.

The Alternative Fuel Infrastructure Assessment is Inadequate and Incorrect

As part of the MTE, the Agencies prepared an assessment of the state of the Alternative Fuel Infrastructure as an indicator of the viability of electric and fuel cell vehicles in the marketplace.[402] The assessment relied on three key initial assumptions: 1) the requirements can be met with only a small percentage of electric vehicles (EV); 2) infrastructure and vehicle requirements are evenly distributed; and, 3) today's customers and vehicles will not change. These assumptions are flawed, over-simplified, and lead to incorrect conclusions about the sufficiency of and the need for infrastructure.

In fact, the Draft TAR does not contain any assessment of the infrastructure needs based on the location of current PEVs or the location of PEVs required by states that have adopted the ZEV regulations. Instead, the Agencies simply assume that all PEVs and all charge points are appropriately distributed throughout the country. The Draft TAR ignores media reports on the scarcity of charging in California,[403] the largest ZEV market in the U.S., and the significant increase in ZEVs required by the ZEV regulations in the 2018 to 2025 timeframe. Moreover, the Draft TAR does not consider the vital role that infrastructure plays in accelerating customer acceptance of PEVs in the market place to increase their appeal to an expanded mainstream customer base.

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[402] 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, (EPA-420-D-16-900, July 2016) at 9-15 et seq.
[403] *See* for example, "In California, Electric Cars Outpace Plugs, and Sparks Fly. *The New York Times.* October 10, 2015. Retrieved from http://www.nytimes.com.

Level 1 Charging will not be a long term solution:

The Draft TAR suggests that the majority of charging can be accomplished using a Level 1 (120V) solution provided by the automotive manufacturer with the vehicle.[404] The Alliance agrees that today the primary charging location for EV is at home and that many customers use the manufacturer-provided Level 1 charge cord. However, several auto manufacturers have already announced increased ranges for both BEV and PHEV making Level 1 charging irrelevant due to longer charge times reducing the suitability of overnight charging using the Level 1 cord. As noted by the Agencies, the practicality of Level 1 reduced in light of larger battery capacity and vehicle range.[405]

The Draft TAR ignores the fact that to sustain sales of EVs, customers need to see an EV as a viable alternative with transparent functionality compared to the traditional ICE vehicle. The ICE vehicle owner generally has a range of over 300 miles and refills in a short period of time as needed at a gas station that can be paid for using the same method at all locations and can be used on daily commutes as well as longer destination travel. BEVs, on the other hand, require substantial charging time even with Level 2 charging, making home, workplace, and public charging essential for mainstream customers.

Finally, with regard to cost, the Draft TAR assumes little additional expense for home charging infrastructure, citing a large portion of charging needs are currently being met by existing access to a standard 120V outlet.

> Most, if not all, OEMs provide a Level 1 cord set at no additional charge with each sale or lease of a PEV. Since the cost of the Level 1 cord set is factored into the price of the vehicle, there is no additional out-of-pocket expense to the consumer opting to use this option to charge their vehicle.[406]

However, not every garage or driveway has access to 120V charging, particularly in older neighborhoods. And, as the Draft TAR pointed out, 36% of residences do not have dedicated parking and require an alternate charging solution.[407]

Further, as mentioned above, increased volume of longer range electrified products will increase the need for Level 2 solutions to maintain overnight charging, which typically carry installation costs in the range of $2,000. National building codes requiring conduit and panel capacity for new construction or significant renovations and/or to require station installation will help to

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[404] 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, (EPA-420-D-16-900, July 2016) at 9-3
[405] *Id.* at 9-4.
[406] *Id.* at 9-3.
[407] *Id.* at 9-20.

reduce future installation costs and assist with customer acceptance by reducing installation challenges, but these enablers are not widely in place.

DC Charging allows EVs to be utilized as a conventional ICE vehicle:

The statement that the more expensive direct current (DC) infrastructure is used for the fewest charging events[408] is based on current usage and minimizes the importance of DC charging for future customer acceptance. A growing number of vehicles are equipped with DC capabilities as vehicle range and DC station installations increase, which will result in increased station utilization. DC stations allow for increased vehicle utilization which could allow for customers to replace their ICE vehicles with EV thereby increasing vehicle sales opportunities. DC may also be a required enabler for multi-unit dwellings (MUDs).

Insufficent Charging Infrastructure to Support Future Growth:

As discussed above, significant growth in electrified products will be required to meet future ZEV regulations. The majority of sales today is concentrated in those regions which mandate sale of electrified products, and have provided significant market support (infrastructure, incentives, etc.) to encourage their sale. However, broader penetration to the mainstream customer will be required to meet future higher sales.

The Draft TAR references the NREL study conducted on behalf of the California Energy Commission (CEC), noting "NREL calculated that the minimum ratio of non-home based charge points (both workplace and public) to PEVs is 0.14 charge points per PEV in the home dominate scenario and 0.24 in the high public access scenario."[409] However, the current EV infrastructure is not sufficient to support even the current number of PEVs when the distribution of PEVs is considered.

Further, the Agencies need to consider, per the discussion above, the need for charging to accommodate products with longer EV range, and for customers in MUDs and residences without dedicated parking.

Table 9-1 shows the PEV population and charge points as of September 11, 2016 in the states that have adopted ZEV regulations.

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[408] *Id.* at 9-77.
[409] *Id.* at 9-24.

Table 9-1: Plug-in Vehicle Population by State and Ratio of Plug-In Vehicles to Charge Points[410,411]

State	BEV Population*	PHEV Population*	Total PEV	Actual Charge Points**	Ratio BEV Only	Ratio All PEV
CA	110,599	105,322	215,921	10,478	0.09	0.05
CT	1,592	2,758	4,350	510	0.32	0.12
MA	2,857	4,558	7,415	1,116	0.39	0.15
MD	2,470	4,529	6,999	972	0.39	0.14
ME	191	852	1,043	150	0.79	0.14
NJ	3,354	6,127	9,481	431	0.13	0.05
NY	4,571	12,462	17,033	1,427	0.31	0.08
OR	5,829	3,655	9,484	1,091	0.19	0.12
RI	203	540	743	195	0.96	0.26
VT	275	1,068	1,343	334	1.21	0.25
Total	131,941	141,871	273,812	16,704	0.13	0.06

The Agencies make a couple of assumptions that warrant more consideration, as discussed below.

BEV Only

The Draft TAR proposes that

> [i]ntuitively, it is less likely that PHEV adoption rates are as dependent upon robust EV infrastructure as BEVs. Given this important distinction, the question of infrastructure sufficiency will be addressed for BEVs by examining a snapshot

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410 BEV, PHEV population based on data from IHS Automotive (January, 2011 through May, 2016).

411 Actual charge points from Department of Energy Alternative Fuels Data Center. Accessed September 11, 2016. http://www.afdc.energy.gov/fuels/electricity_locations.html.

of current BEV numbers in relationship to the EV landscape and trends, and comparing that relationship to work performed by NREL for the CEC.[412]

The Alliance agrees that PHEV adoption will be less impacted by the current and future lack of adequate infrastructure. However, considering only BEVs when looking at PEV infrastructure ignores that PHEVs do use the infrastructure and potentially displace BEVs. The Alliance knows of no public or workplace chargers currently prohibit charging by PHEVs. Thus, the analysis must include all PEVs, since all PEVs will use the infrastructure regardless of need.

Moreover, limiting the analysis to BEVs ignores the longer range PHEVs coming to market, their need for Level 2 workplace and public charging, and the environmental benefit associated with operating those on electricity. For example, the 2017 Chevrolet Volt has a 53 mile all-electric range, but requires between 12 and 19 hours for a full charge using Level 1 charging. The Chrysler Pacifica Hybrid has a similar-sized battery. Level 1 charging might not be sufficient for high mileage drivers, and would certainly prevent substantial grid benefits associated with charging during off-peak hours. Consequently, to maximize the benefit to both society and the driver, workplace and public level 2 charging is needed. The Draft TAR analysis ignores these points.

Home Dominate Scenario

The Draft TAR selects the home dominate scenario ratio of 0.14, citing "[s]tudies have shown that, on average, over 80% of all charging events occur at home."[413] However, the relationship between the number of charging events at home and public charging is not clear. That is, do over 80% of all charging events occur at home because of a lack of public infrastructure? Would 80% of all charging events occur at home if sufficient public charging existed? As noted in Table 9-1, the ratio of PEVs to charge points is far below the minimum number determined by NREL. In determining the number of charge points needed, the Agencies should, at a minimum, select a mid-point between the home dominate and public dominate (i.e., 0.19). Regardless, the current number of public charge points is insufficient by any measure.

It is also premature to simply assume that infrastructure will expand sufficiently on its own. At this point, it is difficult (if not impossible) to recoup the high costs associated with installing public infrastructure, even with federal, state, and local incentives.[414]

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[412] 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, (EPA-420-D-16-900, July 2016) at 9-24.
[413] *Id.* at 9-24.
[414] "Financial Viability of Non-Residential Electric Vehicle Charging Stations." Luskin Center for Innovation, School of Management, University of California Los Angeles. 2012. Accessed September 26, 2016. http://luskin.ucla.edu/sites/default/files/Non-Residential%20Charging%20Stations.pdf.

Finally, it is not sufficient to develop the infrastructure "as needed." Range anxiety and customer awareness inhibit mainstream customer acceptance of ZEVs. Infrastructure installation must lead vehicle sales to raise customer awareness, address range anxiety, and demonstrate infrastructure is available to support customer needs.

Solutions for customers with non-designated parking are required to address a significant portion of the population

The Draft TAR rightly identifies MUDs as a challenge because of the variety of solutions required to address the multitude of possibilities associated with this type of housing.[415] Also, since a significant portion of the population (36% per the Draft TAR) living under these conditions, solutions are needed to support the continued market growth.[416] In the unlikely event that Level 1 charging is a viable option at MUDs, it may not meet the customers' charging needs, especially if overnight charging is not be possible. MUDs frequently do not have dedicated parking.

Wireless/Inductive Charging and VGI

The Draft TAR also suggests that wireless/inductive charging may be a challenge as well as an opportunity. However, the Draft TAR does not recognize that wireless standards have only recently been published by SAE at the TIR level (draft form for first level comments) and that interoperability is not addressed by the requirement meaning that systems cannot yet be used interchangeably, thus limiting installation to residential installations only.[417] There are also concerns with system power levels and electromagnetic frequency (EMF) exposure that have yet to be resolved. In addition, system pricing is significantly greater than conductive systems with similar installation costs, making the package unattractive to many customers.

The Draft TAR discusses the opportunity of vehicle-to-grid interface (VGI) but does not recognize the changes required by both the infrastructure and the vehicle which have yet to be implemented, and the challenge of developing a business case to support implementation. Further, VGI assumes that all stations and vehicles are able to communicate with the grid and/or utility, vehicles are connected to the grid, and that vehicle batteries are not negatively affected by the additional charge/discharge sequences. The Status of the Infrastructure Network suggests that these challenges "are systematically being addressed and infrastructure is progressing

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[415] 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, (EPA-420-D-16-900, July 2016) at 9-25.
[416] *Id.* at 9-25.
[417] "Wireless Power Transfer for Light-Duty Plug-In/ Electric Vehicles and Alignment Methodology." SAE Internation. SAE TIR J2954. Accessed September 26, 2016. http://standards.sae.org/wip/j2954/.

sufficiently to support the scale of the EV market projected in the Draft TAR…"[418] However, the Draft TAR provides nothing to substantiate this conclusion.

Infrastructure Permitting and Cost

Local permitting procedures and building codes can serve as significant barriers to the commercialization of PHEVs and EVs. For example, existing building infrastructure may not have proper electrical service (i.e., service amp rating) to accommodate charging. Multi-unit dwellings and older homes are particularly problematic since they can require substantial retrofitting (e.g. tearing up of asphalt) to install charging stations. In addition, if the transformers that feed the building are not sufficient to handle the electricity volume, this must be upgraded at considerable expense. Further, there may be disagreements where home owner associations or condo associations are unable to accommodate the expensive retrofits, or those who do not drive PEVs are unwilling to approve budget and essentially subsidize those who do.

In addition, in high density areas like inner cities, land and parking is highly valued and the profit margins for turning space into publicly available charging stations are so low that there is no payback or it actually creates a decrease in value (e.g. if the charging station revenue doesn't cover property taxes.) If local, state, and federal governments depend on the infrastructure to be placed on private property, there must be sufficient value for this to be a sustainable business. This situation is made more difficult since charging stations in many cases must be compliant with the Americans with Disabilities Act (ADA) requiring more than one space per charger.

Refueling Costs for PEVs

The analysis of costs to customers for charging should be addressed in detail by the Agencies. In many of the states that have adopted ZEV regulations, the cost of electricity (both at home and especially at pay public charging stations) to charge PEVs could greatly exceed the operating cost of a similar gasoline vehicle.

Looking only at the public charging stations, the rates charged for use at some stations can be four times as high as residential power rates making the costs to operate the PEV substantially higher than operating a similar gasoline vehicle. For example, the Blink Network, which has over 1,200 stations nationwide, charges $0.49/kWh in San Diego–more than twice the cost of operating a similar sized gasoline vehicle.[419] Further, some companies charge a per-session fee for charging which varies dependent on the rate of charging. AeroVironment, for instance, charges $7.50 for fast charging per-session, or $4.00 per session for Level 2 charging. Rates also

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[418] 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, (EPA-420-D-16-900, July 2016) at 9-25.
[419] "Frequently Asked Questions." Blink. Accessed September 26, 2016. http://www.blinknetwork.com/membership-faqs.html

vary among independently owned stations. This rate variation can provide uncertainly for customers.

Many public charging stations also charge a "post occupancy fee" for leaving a fully charged car plugged in, which can be as much as $0.08/minute and can quickly increase the variable cost of this technology, and certainly increases the required customer oversight and interaction.[420] The bottom line is that there is much more to the payback equation for customers than a simple home charging rate analysis can provide. The Agencies should provide a thorough analysis as a part of both the ZEV costs and the GHG/CAFE program to fully inform customers.

Hydrogen Infrastructure

The hydrogen infrastructure, as with the EV infrastructure, needs to be installed in advance of vehicle sales to demonstrate that customers have an ability to fuel the vehicle. Although hydrogen-powered vehicles have longer ranges than current electric vehicles, the infrastructure installation lags considerably, suggesting that hydrogen sales will be limited without significant support. Toyota Mirai vehicle deliveries were delayed because planned installations in California were not completed as expected. Installations are expensive and limited vehicle sales challenge the business case.

Summary

The Draft TAR oversimplifies the infrastructure assessment and does not support the conclusion that installations will continue in advance and at a rate to support continued, accelerated vehicle sales. The conclusions are not valid for today's customers and vehicles and may not hold true for future customers and vehicles, particularly taking into account the announcements already made by automakers on future product capabilities or requirements.

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[420] "Blink Implements Post-Charging Occupancy Fee At Charging Stations" *Inside EVs*. July 2015. Accessed September 26, 2016. http://insideevs.com/blink-implements-post-charging-occupancy-fee-charging-stations/. And "Blink Network Gets Tough on Electric Car Charging Station Hogs, Introduces Post-Charging Occupancy Fee." Transport Evolved. July 13, 2015. Accessed September 26, 2016. https://transportevolved.com/2015/07/13/blink-network-gets-tough-on-electric-car-charging-station-hogs-introduces-post-charging-occupancy-fee/.

Appendix J: Safety Analysis

NHTSA has generated a new dataset of more recent vehicles (MY2003-2010) using the Fatality Analysis Reporting System (FARS) (CY2005-2011). This dataset was released to the public in June 2016 and has been used in the Draft TAR to study various mass reduction scenarios and their effect on safety. This is the first update of safety related to mass and size distribution of the fleet of light vehicles since 2012. Given the short time for comments, it is not possible to conduct an independent analysis of the new dataset. Instead, we have evaluated the Draft TAR at a high level. We find inconsistencies in the conclusions that require further physical explanations.

Using two highly correlated factors, mass and size of vehicles, in a regression analysis can lead to unreliable and non-physical results. Some obvious examples show up in the coefficients for "hit fixed objects" and two vehicle collisions with heavy trucks in the baseline model (Table 3-7 of the 2016 Preliminary Relationship between Fatality Risk, Mass and Footprint 2003-2010 Volpe Report). For example, the regression analysis shows that a 100 lb. reduction in weight of heavier, truck-based LTV (>4947 lbs.) will result in an increase of fatality risk by 1.79% in crashes against fixed objects, but such a weight reduction in cars and other LTVs will reduce the risk in cars and other LTVs. In the case of CUVs and Minivans, the reduction is as much as 3.12% for these vehicles when involved in fixed object collisions. This finding is contrary to NHTSA's past studies, and studies elsewhere in the literature. Another example of inconsistent results is in crashes against heavy vehicles (>10,000 GVWR). The coefficients indicate that reducing the weight of a truck-based LTV (<4947 lbs.) by 100 lbs. will increase the fatality risk by 3.85%, but reducing the weight of a car (<3197 lbs. Curb weight) by 100 lbs. will increase the fatality risk by only 2.57% in collisions against heavy vehicles (see Table 3-7 of 2016 Volpe report). Higher increases in fatality risks in the lighter cars and LTVs are expected.

The Alliance also finds inconsistencies in the results between the 2016 Volpe Report (Table 3-7) and Table 8.7 of the Draft TAR. Both address the 100 lbs. reduction of the entire fleet of light vehicles. The estimated increase reported by Volpe is 91, but the increase in the Draft TAR is 55. No explanation for the difference between the two estimates is proffered.

Table 8.7 in the Draft TAR shows the estimated annual change in fatalities from six different fleet wide mass reduction scenarios. It is obvious that the three different estimates (2012 NHTSA baseline, 2016 NHTSA baseline, and the 2016 DRI measures) do not agree in their effects or actual numbers. For example, the 2012 NHTSA scenario 6 (NRC-suggested weight reduction of the fleet) indicates an increase of 224 annual fatalities; the 2016 NHTSA baseline indicates a reduction of 220 annual fatalities; and the 2016 DRI measures indicates an annual reduction of 1306 fatalities. Such differences in projections require further studies to explain the results.

With the current conflicting results from statistical modeling, it is advisable to pursue a standard, and underlying technology pathways, that are safety neutral. This includes being judicious in weight reduction of LTVs.

Appendix K: Miscellaneous Issues

Comment Period and Schedule for Completing the MTE

TAR Comment Period Extension Request

The Draft TAR spans more than 1,200 pages and incorporates the findings of dozens of separate studies, many of which were not previously available for public comment. The Alliance is still evaluating the Draft TAR and identifying data upon which the Agencies relied to run the five models (ALPHA, LPM, OMEGA, Autonomie and the Volpe model) that serve as the basis for the MTE, and to understand how the data was used. On August 1, 2016, the Alliance submitted a request for an extension of the 60-day comment period, which was subsequently denied by the Agencies.[421]

The Comment Period Specified for the Draft TAR Should Not Preclude Additional Technical Comments on the Proposed Determination and/or NPRM

For the reasons explained in the Alliance's August 1, 2016,[422] request for an extension of time to comment on the Draft TAR, the Alliance asserts that 60 days was not sufficient time to review and provide full input on all of the complex technical analyses in the Draft TAR. As expressed previously, the Alliance anticipates that the Agencies will respond formally to comments that may need to be submitted after the close of the 60-day comment period, and expects that the Agencies will do so prior to issuing a proposed decision and NPRM to ensure that the next steps of the MTE include the most up-to-date information.[423]

Moreover, it is important to clarify the legal effect of the comment period on the Draft TAR. The Draft TAR is not a decision document and thus is not "Agency action" or a "proposed rule" within the meaning of the Clean Air Act (CAA) or the Administrative Procedure Act (APA), because it is intended only to inform the MTE, and does not itself have or propose to have legal consequences.[424] The Agencies' proposed actions (whether a proposed determination or NPRM), on the other hand, are formal rulemakings and thus must be accompanied by, among other things, a statement of the rule's basis and the factual data and methodology relied upon. As such, irrespective of any deadline to comment on the Draft TAR, the public must have an

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[421] Docket ID EPA-HQ-OAR-2015-0827-0928.
[422] *Id.*
[423] Docket ID EPA-HQ-OAR-2015-0827-3292.
[424] *See* 5 U.S.C. § 551(4) (defining "rule" to mean "the whole or a part of an Agency statement of general or particular applicability and future effect designed to implement, interpret, or prescribe law or policy or describing the organization, procedure, or practice requirements of an Agency . . ."), § 551(13) (defining "Agency action" to include "the whole or a part of an Agency rule, order, license, sanction, relief, or the equivalent or denial thereof, or failure to act").

opportunity to comment fully on the Agencies' proposed decisions. To the extent that EPA or NHTSA relies on any aspect of the Draft TAR in their proposed actions, the Agencies must take comment on those issues during the post-proposal comment period, and must address all such comments in their final determination and/or final rulemaking.[425] Likewise, to the extent that the Agencies rely on revised conclusions from the Draft TAR (taking into account input on the Draft TAR or other subsequent developments) in their proposed determination and/or rule, the basis for those revised conclusions similarly would be subject to public comment. In other words, the comment period on the Draft TAR must be in addition to, and not to the exclusion of, an opportunity to comment on the proposed decisions, including the basis for those decisions, at a later stage. Based on the Agencies' June 10, 2016 letter to the Hon. Ed Whitfield, the Alliance trusts that the Agencies agree with this analysis.

Analysis of Letter Denying Extension

In the letter denying the Alliance and Global Automaker's extension request,[426] the Agencies note that the both the EPA and NTHSA websites have provided information for more than 18 months. Although the websites contained some referenced data studies, the over 1,200 pages of the Draft TAR and much of the modeling was not released before the comment period. Additionally, since a primary component of commenting on a document is understanding how cited references are applied, simply posting references is of little help in the review and comment process.

The denial letter also notes that EPA has published more than 25 peer reviewed papers that stakeholders could have reviewed, that the Agencies have presented at several technical conferences to keep stakeholders informed of the Agency work, and that the Agencies held a public modeling workshop in March 2016.[427]

Peer review, though valuable, is not the same thing as public review and comment. Most of the EPA technical papers and studies were published through the Society of Automotive Engineers (SAE), whose peer review process consists of SAE members who self-identify as qualified peer reviewers. Except for a few questions being allowed in technical conferences and at the single modeling workshop, there was no opportunity for dialogue with the Agencies. With the exception of the March 2016 workshop,[428] the conferences referred to were not free.

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[425] *See* 42 U.S.C. 7607(d)(6)(B) (requiring the promulgated rule to "be accompanied by a response to each of the significant comments, criticisms, and new data submitted in written or oral presentations during the comment period"); 5 U.S.C. § 553 (requiring Agencies to give "interested persons an opportunity to participate in the rule making through submission of written data, views, or arguments" and to consider the "relevant matter presented").
[426] Docket ID EPA-HQ-OAR-2015-0827-1129.
[427] *Id.*
[428] "NHTSA, EPA and CARB workshop on technology effectiveness modeling methodologies for the midterm evaluation draft technical assessment report (TAR) analysis for CAFE standards and GHG standards." National

Before the Draft TAR was released, the EPA did not release model input/output files or the updated OMEGA, ALPHA, or lumped parameter models. Even where individual manufacturers provided data to test the models, the Agencies did not share their results. Also, notably, there were not any public workshops on other key issues such as customer acceptance, impact on employment or impact on the U.S. economy.

Over the last two years, the Alliance has made a good faith effort to express its concerns and questions about Agency methodology and assumptions (technology, customer acceptance, modeling, etc.), to support the Agencies with detailed information to help resolve uncertainties. The Alliance is now being afforded only 60 days to digest how the Agencies have responded to two years of resource-intensive industry input to the Draft TAR.

Finally, EPA has only recently publicized significant changes in its consideration of cost and effectiveness of key technologies in the Draft TAR (e.g. dropping GTDI penetration significantly, adding mild hybrids and advanced Atkinson engines).

Although our request for a longer comment period has not been granted, Agency management has indicated that comments received after September 26, 2016 will be considered. The Alliance may submit supplemental attachments to our comments as the information becomes available to complete our own analyses. As stated in our letter responding to the Agencies' denial letter, we expect the TAR comments, including the comments submitted after the September 26, 2016 deadline, will be taken into consideration in next steps of the MTE.

The Agencies Should Clarify Their Anticipated Schedule for Completing the MTE and Coordinating with CARB

The Alliance believes that it would be helpful to all stakeholders for the Agencies to explain their current anticipated schedule for completing the MTE process following issuance of the Draft TAR. The Alliance recognizes that EPA declined in the 2012 FRM to commit to a specific schedule beyond those items identified above.[429] Nevertheless, the Alliance believes that the Agencies should explain their current intentions regarding: (1) whether (and if so, when) the Agencies intend to issue a Final TAR; (2) when the Agencies expect to issue a proposed determination and/or NPRM; (3) the specific timing of the joint final rule if EPA determines that the MY2022-2025 are not appropriate; and (4) the Agencies' own schedule for further consideration of particular technical topics. In this manner, stakeholders may best prioritize their own resources to provide timely input that is most helpful to the Agencies' decision-making.

Highway Traffic Safety Administration. Accessed September 26, 2016.
http://www.nhtsa.gov/Laws+&+Regulations/CAFE+-+Fuel+Economy/nhtsa-epa-carb-workshop-03012016.
[429] 77 Fed. Reg. 62624, 62787 (Oct. 15, 2012).

Finally, the Alliance notes that CARB is a joint issuer of the Draft TAR and is pursuing its own midterm evaluation. EPA and NHTSA should seek to be transparent in their coordination with CARB, and should ensure that the midterm evaluations being performed by the federal Agencies and CARB are aligned, particularly in regard to the schedule for their respective actions. Plainly, where complicated technical issues are the subject of ongoing analyses that may evolve with new information on a continuous basis, it makes sense for EPA, NHTSA and CARB to consider that information consistently and at the same time. Otherwise, unwarranted inconsistencies may arise due to differences in the factual or informational basis for the decisions.

Draft TAR Comments on VMT Calculations

In Section 13.1.4 of the Draft TAR,[430] NHTSA discusses a new method of determining VMT. While the previous method was based on data from National Household Travel Surveys (NHTS), the proposed method is based on a purchased data set of odometer readings from IHS/Polk.[431]

The new method yielded approximately 20% lower survival weighted, lifetime VMTs for most light-duty vehicles (Table 13.1). This is a significant reduction that requires greater explanation and understanding before any action is taken. Of great concern for manufacturers is the fact that VMTs affect the adjustment factors used in credit trades and transfers.[432] Any changes in VMT calculation methodology will affect the value of credits already earned or expected to be earned from future product plans.

We also note that EPA uses VMT in its calculation of GHG credits.[433] Since vehicles simultaneously consume fuel and emit CO_2, we believe it is only logical that both Agencies use the same VMT in their calculations. For stability and harmonization in the GHG and CAFE programs, we believe that future VMT should remain at the present levels of 195,264 for passenger cars and 225,865 for light-duty trucks.[434]

MOVES Modeling

The Alliance recommends that EPA investigate updates to the Motor Vehicle Emission Simulator (MOVES) model[435] deceleration / coasting bins to more accurately reflect on-road activity data. Currently the MOVES model lumps all coasting, mild braking, and aggressive braking activity data into one bin. Given the emergence of new technologies such as BEVs,

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[430] 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, (EPA-420-D-16-900, July 2016) at 13-11.
[431] *Id.* at 13.-11.
[432] 49 CFR § 536.4.
[433] 40 CFR § 86.1865-12(k)(4).
[434] Id.
[435] "MOVES (Motor Vehicle Emission Simulator)." U.S. Environmental Protection Agency. Accessed September 26, 2016. https://www3.epa.gov/otaq/models/moves/.

HEVs, mild HEVs, alternator regeneration, and rolling stop, the Alliance recommends that EPA consider the addition of three new MOVES vehicle specific power bins to account for future on-road benefits of these types of systems.

Separate Car and Truck Standards

The Alliance continues to support maintaining separate, but comparably stringent, GHG and FE standards for passenger cars and light trucks. Car and trucks have unique attributes that require differing standards.