Final Determination on the Appropriateness of the Model Year 2022-2025 Light-Duty Vehicle Greenhouse Gas Emissions Standards under the Midterm Evaluation

Response to Comments

EPA United States Environmental Protection Agency

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U.S. Environmental Protection Agency
Assessment and Standards Division

United States Environmental Protection Agency

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List of Acronyms

2MHEV	2-Mode Hybrid
ABS	Anti-lock Braking System
ABT	Averaging, Banking, and Trading
AC	Alternating Current
A/C	Air Conditioning
ACEEE	American Council for an Energy-Efficient Economy
AEO	Annual Energy Outlook
AER	All-Electric Range
AFDC	Alternative Fuels Data Center
AGM	Absorbent Glass Mat
AHSS	Advanced High Strength Steel
ALPHA	Advanced Light-Duty Powertrain and Hybrid Analysis Tool
AMT	Automated Manual Transmission
ANL	Argonne National Laboratory
ARB	California Air Resources Board
ASI	Area Specific Impedance
ASL	Aggressive Shift Logic
ASM	Annual Survey of Manufacturers
AT	Automatic Transmissions
Avg	Average
AWD	All Wheel Drive
BenMAP	Benefits Mapping and Analysis Program
BEV	Battery Electric Vehicle
BISG	Belt Integrated Starter Generator
BIW	Body-In-White
BLS	Bureau of Labor Statistics
BMEP	Brake Mean Effective Pressure
BOM	Bill of Materials
BSFC	Brake Specific Fuel Consumption
BTE	Brake-Thermal Efficiency
BTU	British Thermal Unit
CAA	Clean Air Act
CAD	Computer Aided Designs
CAD/CAE	Computer Aided Design and Engineering
CAE	Computer Aided Engineering
CAFE	Corporate Average Fuel Economy
CARB	California Air Resources Board
CAVs	Connected and Automated (or autonomous) Vehicles
CBD	Center for Biological Diversity
CBI	Confidential Business Information
CCP	Coupled Cam Phasing

CDPF	Catalyzed Diesel Particulate Filter
CEC	California Energy Commission
cEGR	Cooled Exhaust Gas Recirculation
CES	Consumer Expenditure Survey
CFD	Computational Fluid Dynamics
CFR	Code of Federal Regulations
CH_4	Methane
CISG	Crank Integrated Starter Generator
CNG	Compressed Natural Gas
CO	Carbon Monoxide
COI	Conflict Of Interest
CO_2	Carbon Dioxide
CO_2eq	CO_2 Equivalent
COP	Coefficient of Performance
CSM	Conceptual Site Model
CSV	Comma-separated Values
CUV	Crossover Utility Vehicles
CVT	Continuously Variable Transmission
CY	Calendar Year
DC	Direct Current
DCFC	Direct Carbon Fuel Cell
DCP	Dual Cam Phasing
DCT	Dual Clutch Transmission
DEAC	Cylinder Deactivation
DFMA	Design for Manufacturing and Assembly
DGS	California Department of General Services
DICE	Dynamic Integrated Climate and Economy
DMC	Direct Manufacturing Costs
DoE	Department of Energy
DOE	Design of Experiments
DOHC	Dual Overhead Camshaft Engines
DOT	Department of Transportation
DRI	Dynamic Research, Inc.
DRLs	Daytime Running Lamps
DVVL	Discrete Variable Valve Lift
EGR	Exhaust Gas Recirculation
EHPS	Electrohydraulic Power Steering
EIA	Energy Information Administration (part of the U.S. Department of Energy)
EISA	Energy Independence and Security Act
EIVC	Early Intake Valve Closing
EPA	Environmental Protection Agency
EPCA	Energy Policy and Conservation Act

EPRI	Electric Power Research Institute
EPS	Electric Power Steering
EPS	Energy Power Systems
EREV	Extended Range Electric Vehicle
ERM	Employment Requirements Matrix
ESC	Electronic Stability Control
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment
FARS	Fatality Analysis Reporting System
FCEV	Fuel Cell Electric Vehicle
FCPM	Fuel Cost Per Mile
FCEV	Fuel Cell Electric Vehicle
FE	Finite Element
FEV1	Functional Expiratory Volume
FHWA	Federal Highway Administration
FMEP	Friction Mean Effective Pressure
FMVSS	Federal Motor Vehicle Safety Standards
FR	Federal Register
FRIA	Final Regulatory Impact Analysis
FRM	Final Rulemaking
FTP	Federal Test Procedure
gal/mi	Gallon/Mile
GCWR	Gross Combined Weight Rating
GDI	Gasoline Direct Injection
GDP	Gross Domestic Product
GEM	Greenhouse gas Emissions Model
GHG	Greenhouse Gases
GREET	Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation
GVW	Gross Vehicle Weight
GWP	Global Warming Potential
GWU	George Washington University
HD	Heavy-Duty
HEV	Hybrid Electric Vehicle
HFC	Hydrofluorocarbon
HFET	Highway Fuel Economy Dynamometer Procedure
HIL	Hardware-In-Loop
hp	Horsepower
hrs	Hours
HP/WT	Horsepower Divided by Weight
HVAC	Heating, Ventilating, And Air Conditioning
hz	Hertz
IACC	Improved Accessories

IAM	Integrated Assessment Models
IATC	Improved Automatic Transmission Control
IC	Indirect Cost
ICCT	International Council on Clean Transportation
ICF	ICF International
ICM	Indirect Cost Multiplier
IHX	Internal Heat Exchanger
IMA	Improved Mobile Assist
IMAC	Improved Mobile Air Conditioning
INL	Idaho National Laboratory
IOU	Investor Owned Utilities
IPCC	Intergovernmental Panel on Climate Change
IPM	Integrated Planning Model
ITC	Institute of Transportation Studies
IWG	Interagency Working Group
k	Thousand
kg	Kilogram
kW	Kilowatt
kWh	kilowatt-hour
L	Liter
lb	Pound
LBNL	Lawrence Berkeley National Laboratory
LD	Light-Duty
LEV	Low-Emission Vehicle
LHD	Light Heavy-Duty
LDV	Light Duty Vehicle
LNT	Lean NO_X Trap
LPM	Lumped Parameter Model
LRR	Lower Rolling Resistance
LT	Light Trucks
LWT	Lightweighted Pickup Truck
MAD	Minimum Absolute Deviation
MBPD	Million Barrels Per Day
MD	Medium-Duty
MDPV	Medium-Duty Passenger Vehicles
MEMA	Motor Equipment Manufacturers Association
Mg	Megagram
mg	Milligram
MHEV	Mild Hybrid Electric Vehicle
mi	mile
min	minimum
min	Minute
MM	Million

MMLV	Multi-Material Lightweight Vehicle
MMT	Million Metric Tons
MOVES	Motor Vehicle Emissions Simulator
mpg	Miles per Gallon
mph	Miles per Hour
MPV	Multi-Purpose Vehicle
MSRP	Manufacturer’s Suggested Retail Price
MTE	Mid Term Evaluation
MuD	Multi-Unit Development
MY	Model Year
N_2O	Nitrous Oxide
NA	Not Applicable
NAAQS	National Ambient Air Quality Standards
NADA	National Automobile Dealers Association
NAS	National Academy of Sciences
NCA	National Climate Assessment
NCAP	New Car Assessment Program
NEMS	National Energy Modeling System
NESHAP	National Emissions Standards for Hazardous Air Pollutants
NF_3	Nitrogen Trifluoride
NGO	Non-Governmental Organization
NHTSA	National Highway Traffic Safety Administration
NiMH	Nickel Metal-Hydride
NF_3	Nitrogen Trifluoride
NO_X	Nitrogen Oxides
NO_2	Nitrogen Dioxide
NO_X	Oxides of Nitrogen
NPRM	Notice of Proposed Rulemaking
NRC	National Research Council
NRC-CAN	National Research Council of Canada
NREL	National Renewable Energy Laboratory
NVH	Noise Vibration and Harshness
NVPP	National Vehicle Population Profiles
OAR	EPA's Office of Air and Radiation
OEM	Original Equipment Manufacturer
OECD	Organization for Economic Cooperation and Development
OHV	Overhead Valve
OLS	Ordinary Least Squares
OMB	EPA's Office of Management and Budget
OPEC	Organization of Petroleum Exporting Countries
ORNL	Oak Ridge National Laboratory
OTAQ	EPA's Office of Transportation and Air Quality
PAGE	Policy Analysis of the Greenhouse Effect

PC	Passenger Car
P/E	Power-to-Energy
PEF	Peak Expiratory Flow
PEV	Plug-in Electric Vehicle
PFCs	Perfluorocarbons
PFI	Port-fuel-injection
PGM	Platinum Group Metal
PHEV	Plug-in Hybrid Electric Vehicle
PLM	Planar Layered Matrix
PM	Particulate Matter
$PM_{2.5}$	Fine Particulate Matter (diameter of 2.5 µm or less)
PMSMs	Permanent-Magnet Synchronous Motors
PSHEV	Power-split Hybrid
PSI	Pounds per Square Inch
PWM	Pulse-width Modulated
R&D	Research and Development
RFS2	Renewable Fuel Standard 2
RIA	Regulatory Impact Analysis
RPE	Retail Price Equivalent
RPM	Revolutions per Minute
RSM	Response Surface Models
RTI	RTI International (formerly Research Triangle Institute)
SA	Strategic Analysis, Inc.
SAB	Science Advisory Board
SAB-EEAC	Science Advisory Board Environmental Economics Advisory Committee
SAE	Society of Automotive Engineers
$SC0_3$	Soak Control third iteration
SCC	Social Cost of Carbon
SCR	Selective Catalyst Reduction
SF_6	Sulfur Hexafluoride
SGDI	Stoichiometric Gasoline Direct Injection
SHEV	Strong Hybrid Electric Vehicles
SI	Spark-Ignition
SIDI	Spark Ignition Direct Injection
SIL	Software-In-Loop
SMDI	Steel Market Development Institutes
SNAP	Significant New Alternatives Policy
SNPRM	Supplemental Notice of Proposed Rulemaking
SO_2	Sulfur Dioxide
SO_x	Sulfur Oxides
SOC	State of Charge

SOHC	Single Overhead Cam
SOL	Small Overlap
SPR	Strategic Petroleum Reserve
Std	Standard
SUV	Sport Utility Vehicle
TAR	Technical Assessment Report
TC	Total Costs
TCIP	Tire Consumer Information Program
TDC	Top Dead Center
Tds	Direct Solar Transmittance
TFECIP	Tire Fuel Efficiency Consumer Information Program
TPE	Total Primary Energy
TRBDS	Turbocharging and Downsizing
TSD	Technical Support Document
UMTRI	University of Michigan Transportation Research Institute
UTQGS	Uniform Tire Quality Grading Standards
V2V	Vehicle-To-Vehicle
VGI	Vehicle Grid Integration
VIF	Variance Inflation Factor
VMT	Vehicle Miles Traveled
VOC	Volatile Organic Compound
VSL	Vehicle Speed Limiter
VVL	Variable Valve Lift
VVT	Variable Valve Timing
WT/FP	Weight Divided by Footprint
ZEV	Zero Emission Vehicle

Introduction

The 2012 rulemaking establishing the National Program for federal greenhouse gas (GHG) emissions and corporate average fuel economy (CAFE) standards for model years (MY) 2017-2025 light-duty vehicles included a regulatory requirement for the Environmental Protection Agency (EPA) to conduct a Midterm Evaluation (MTE) of the GHG standards established for MY2022-2025.[1] In the Final Determination that this document accompanies, the Administrator is making a final adjudicatory determination (hereafter "Final Determination") that, based on her evaluation of extensive technical information available to her and significant input from the industry and other stakeholders, and in light of the factors listed in the 2012 final rule establishing the MY2017-2025 standards, the MY2022-2025 standards remain appropriate under section 202(a)(1) of the Clean Air Act. The Final Determination leaves those standards entirely as they now exist, unaltered.

The Final Determination follows the November 2016 Proposed Determination issued by the EPA Administrator and the July 2016 release of a Draft Technical Assessment Report (TAR), issued jointly by the EPA, the National Highway Traffic Safety Administration (NHTSA), and the California Air Resources Board (CARB). Opportunities for public comment were provided for both the Draft TAR and the Proposed Determination. In the Draft TAR, the agencies examined a wide range of issues relevant to GHG emissions standards for MY2022-2025, and shared with the public their initial technical analyses of those issues. The Draft TAR was required by EPA's regulations as the first step in the Midterm Evaluation process. In developing the Proposed Determination, the Administrator considered public comments on the Draft TAR and EPA updated its analyses where appropriate in response to comments and to reflect the latest available data. The Administrator has likewise considered public input on the Proposed Determination in developing the Final Determination.

EPA received more than 100,000 public comments on the Proposed Determination, with comments from about 60 organizations and the rest from individuals, the vast majority of which are from mass comment campaigns. These public comments have informed the Administrator's Final Determination, and EPA has responded to the comments in this Response to Comments (RTC) document. Many of the comments received included the same or similar information as that we received on the Draft TAR, to which we previously responded in the Proposed Determination document and its accompanying Technical Support Document (TSD). This RTC document, together with the Final Determination, Proposed Determination, the Appendices to the Proposed Determination, and the TSD to the Proposed Determination should be considered collectively as EPA's response to all of the significant comments received on EPA's Midterm Evaluation.[2]

[1] 40 CFR 86.1818-12(h).

[2] The Final Determination, this RTC document, the Proposed Determination, the Appendices to the Proposed Determination, and the TSD to the Proposed Determination are contained in EPA Docket ID No. EPA-HQ-OAR-2015-0827 and can be found at https://www.epa.gov/regulations-emissions-vehicles-and-engines/midterm-evaluation-light-duty-vehicle-greenhouse-gas-ghg.

List of Commenters for the Proposed Determination

The following represents the list of commenter who submitted comments on the Proposed Determination:

Acadia Center et al.
Achates Power, Inc.
Adsorbed Natural Gas Products, Inc. (ANGP)
Advanced Biofuels USA
Alliance of Automobile Manufacturers
American Chemistry Council (ACC)
American Coalition for Ethanol (ACE)
American Council for an Energy-Efficient Economy (ACEEE)
American Iron and Steel Institute (AISI)
American Lung Association et al.
BlueGreen Alliance
BMW Group
Boyden Grey & Associates PLLC on behalf of Energy Future Coalition (EFC) and Urban Air Initiative (UAI)
Business for Innovative Climate and Energy Policy (BICEP), a project of Ceres
California Air Resources Board (CARB)
California State Legislature et al.
California State Teachers' Retirement System et al.
Carnegie Mellon University et al.
Center for Automotive Research (CAR)
Center for Biological Diversity (CBD)
Consumer Federation of America (CFA)
Consumers Union (CU)
Denso International America, Inc.
Edison Electric Institute (EEI)
Enhanced Protective Glass Automotive Association (EPGAA)
Environmental Defense Fund (EDF) et al.
Faraday Future
Fiat Chrysler Automobiles U.S. LLC (FCA)
Ford Motor Company
Fuel Freedom Foundation
General Motors
Growth Energy
Heritage Foundation
High Octane, Low Carbon (HOLC)
Honda Motor Co., Inc.
Honeywell
Institute for Energy Research (IER)
International Council on Clean Transportation (ICCT)
Manufacturers of Emission Controls Association (MECA)
Mercedes-Benz USA, LLC and Daimler AG
Michigan League of Conservation Voters (LCV)

Mike DeWine, Ohio Attorney General and Bill Schuette, Michigan Attorney General
Minnesota Corn Growers Association (MCGA) and the
Illinois Corn Growers Association (ICGA)
Motor & Equipment Manufacturers Association (MEMA)
National Association of Clean Air Agencies (NACAA)
National Association of Manufacturers (NAM)
National Automobile Dealers Association (NADA)
National Corn Growers Association (NCGA)
Natural Resources Defense Council (NRDC)
New York State Department of Environmental Conservation (NYSDEC)
Nissan North America, Inc.
Northeast States for Coordinated Air Use Management (NESCAUM)
Novation Analytics
Pittsburgh Glass Works, LLC
Renewable Fuels Association (RFA)
Suburu
The Association of Global Automakers, Inc. (Global Automakers)
Toyota Motor North America, Inc.
U.S Chamber of Commerce
Union of Concerned Scientists
United Automobile, Aerospace and Agricultural Implement Workers of America (UAW)
Utah Physicians for a Healthy Environment (UPHE)

Mass Comment Campaign sponsored by Environment America
Mass Comment Campaign sponsored by Environmental Defense Fund (EDF)
Mass Comment Campaign sponsored by Fuel Freedom Foundation
Mass Comment Campaign sponsored by Moms Clean Air Force
Mass Comment Campaign sponsored by Natural Resources Defense Council (NRDC)
Mass Comment Campaign sponsored by Union of Concerned Scientists (UCS)
Mass Comment Campaign sponsored by Washington Environmental Council (WEC)
4 Mass Comment Campaigns sponsored by unknown organizations

149 unique private citizen comments
65 anonymous public comments

Chapter 1: General and Process

1.1 General Comments

We received a large number of broad comments on the Proposed Determination that are not on any specific aspect of the Proposed Determination, but rather are directed generally at the Proposed Determination finding that the MY2022-2025 standards remain appropriate under section 202(a)(1) of the Clean Air Act. These general comments include those from both organizations and private citizens.

Many comments generally supported the Proposed Determination finding that the MY2022-2025 standards remain appropriate. Examples of these types of comments include those from Achates Power, American Council for an Energy-Efficient Economy (ACEEE), Consumers Union, Edison Electric Institute, Honeywell, Manufacturers of Emission Controls Association, the California Legislature, the California Air Resources Board (CARB), the BlueGreen Alliance, and others. Some commenters further agreed that the record supports strengthening the standards, including the International Council on Clean Transportation (ICCT), the Natural Resources Defense Council (NRDC), the National Association of Clean Air Agencies (NACAA), Northeast States for Coordinated Air Use Management (NESCAUM), Environmental Defense Fund, the Union of Concerned Scientists (UCS), and others.

Other comments generally disagreed with the Proposed Determination; examples of these types of comments include those from the Alliance of Automobile Manufacturers (Alliance), Global Automakers, Ford, General Motors (GM), FCA, Toyota, Nissan, Subaru, the American Iron and Steel Institute (AESI), Motor Equipment Manufacturers Association (MEMA), National Automobile Dealers Association (NADA), U.S. Chamber of Commerce, National Association of Manufacturers (NAM), Adsorbed Natural Gas Produces (ANGP), High Octane Low Carbon, National Corn Growers, Minnesota and Illinois Corn Growers Associations, and the Energy Future Coalition.

We appreciate the time and effort taken by the commenters in developing their comments, both on the Proposed Determination specifically, and during the many opportunities for public input throughout the Midterm Evaluation process. We have carefully considered public input on the Proposed Determination, and these public comments have informed the Administrator’s Final Determination.

Based on her evaluation of extensive technical information available to her and significant input from stakeholders, and in light of the factors listed in the 2012 final rule establishing the MY2017-2025 standards, the Administrator is making a final adjudicatory determination that the MY2022-2025 standards remain appropriate under section 202(a)(1) of the Clean Air Act. We continue to believe that making the Final Determination now recognizes that long-term regulatory certainty and stability are important for the automotive industry and contributes to the continued success of the program, which in turn will reduce emissions, improve fuel economy, deliver significant fuel savings to consumers, and benefit public health and welfare.

We appreciate the support for the Proposed Determination expressed by many of the commenters. In our consideration of comments that expressed general opposition to the Proposed

Determination, we find no information presented in the public comments on the Proposed Determination that leads us to change the Agency's analysis in support of the Proposed Determination. In fact, in many cases, we received similar or identical comments for the Draft TAR and we responded to them in the Proposed Determination. We respond to comments on the Midterm Evaluation process, including the Proposed Determination process and timing, in Section 1.2 below, and to comments on specific aspects of the Proposed Determination throughout other sections of this Response to Comments (RTC) document.

1.2 Legal Process and Timing

Summary of Comments on the Draft TAR addressed in the Proposed Determination

The Executive Summary and Section I.A of the Proposed Determination provided an overview of the Midterm Evaluation (MTE) process established by Environmental Protection Agency (EPA) regulations. EPA did not receive significant comments on the Draft TAR's description of the MTE process.

Summary of Comments on the Proposed Determination

EPA received many comments relating to the process that the Administrator used in issuing the Proposed Determination. Several NGO and state government commenters stated that they believe the process that the Administrator used for this action was appropriate and/or supported the Administrator moving forward with a Final Determination. These included the Environmental Defense Fund, which described its legal conclusions that the Administrator's action is not a rulemaking and that "given the strong and consistent factual record on which the finding is based, it was likewise appropriate for the Administrator to move forward with her proposed adjudicatory determination." Other commenters that agreed that the process was appropriate include the following: Achates Power, Edison Electric Institute, National Association of Clean Air Agencies, Washington Environmental Council, American Council for an Energy-Efficient Economy, International Council on Clean Transportation, Natural Resources Defense Council, Union of Concerned Scientists, and Consumer Federation of America. The Michigan League of Conservation Voters generally supported the Administrator's action to maintain the existing GHG standards, although they would have preferred a 30-day extension of the comment period. The UAW also said it would have preferred "a lengthier midterm review," but also said that the shortened process "should reduce the likelihood of competing standards and will provide certainty to an industry that needs ample lead time to plan for production."

Auto manufacturers and their trade groups strongly expressed concerns about several aspects of the process the Administrator used in issuing the Proposed Determination. Other organizations, such as some automotive suppliers, echoed some of these process concerns raised by the auto manufacturing industry. We describe these comments in more detail and respond to them below. In general, many commenters assert that they were not afforded the required or expected procedures under the Midterm Evaluation. Several commenters also describe why they believe the Final Determination is a rule, and thus they believe it is subject to more procedural requirements than a non-rulemaking action. Commenting on one or more of these issues were the following automobile manufacturers and their trade organizations: The Alliance of Automobile Manufacturers (Alliance), Global Automakers, Ford, GM, FCA, Toyota, Nissan, Subaru, BMW, and Mercedes-Benz. Other commenters expressing similar views on these issues included DENSO, American Iron and Steel Institute, Motor Equipment Manufacturers

Association, National Automobile Dealers Association, U.S. Chamber of Commerce, National Association of Manufacturers, Adsorbed Natural Gas Products, High Octane Low Carbon, National Corn Growers Association, Minnesota and Illinois Corn Growers Associations, and the Energy Future Coalition.

Some commenters, including the Alliance and Global Automakers, commented that by taking action separate from and prior to MTE-related regulatory action by NHTSA and CARB, EPA's current action creates a conflict with the agencies' basic principle of a One National Program (ONP), that allows manufacturers to build a single national light-duty vehicle fleet that complies with EPA, NHTSA, and CARB standards. FCA specifically stated their concern that EPA's treatment of occupant safety comments was related to a perceived lack of coordination with NHTSA.

Response to Comments on the Proposed Determination

Many of the commenters expressed concerns that they had not been afforded the procedures required under the rules establishing the MTE, and that the procedures in any case were not in accord with stakeholders' legitimate expectations. The main contention was that the process was precipitate and afforded inadequate opportunity to properly evaluate and discuss the many technical issues arising under the MTE. Commenters pointed to various preamble statements from the 2012 final rulemaking (FRM) regarding the need for an iterative, data-driven process, other preamble statements indicating that EPA and NHTSA intended to act on concurrent time frames, EPA statements, including web postings, suggesting plans for a lengthier process, all of which commenters view as inconsistent with EPA's process. The Alliance stated that the process has "precluded consideration by EPA of pending studies and more current information."

EPA has followed and complied with all of the procedural steps set out in the rules. In the Notice of Intent describing the second phase of the National Program, which describes the midterm evaluation process, EPA indicated (see 76 FR 48672-673, Aug. 9, 2011) that:

- EPA would conduct a mid-term evaluation of the MY2022-2025 standards to determine whether those standards are appropriate under section 202(a) of the act, and must make a final determination no later than April 1, 2018;

- EPA, NHTSA, and CARB would jointly prepare a Draft Technical Assessment Report (TAR) to inform EPA's determination, and there would be an opportunity for public comment on the Draft TAR, and appropriate peer review of its underlying analyses; and that all assumptions and modeling underlying the Draft TAR would be available for public comment;

- EPA would also seek public comment on whether the standards are appropriate, and would carefully consider and respond to those comments in taking any final action;

- EPA and NHTSA would consult and coordinate in developing EPA's determination of whether the MY2022-2025 standards are appropriate;

- EPA's determination is to be based on a comprehensive, integrated assessment of all the results of its review, as well as any public comments received during the evaluation, taken as a whole; the Administrator is to consider a record at least as robust as that in the rulemaking establishing the standards;

- An EPA decision that the MY2022-2025 standards are appropriate would be final agency action subject to judicial review, and EPA would announce that final decision and the basis for EPA's decision; however, if EPA determines that the standards are not appropriate, EPA must initiate rulemaking to amend the standards.

More specifically, the codified rules on the MTE require that EPA complete the following tasks prior to its final determination: prepare the Draft TAR; seek public comment on the Draft TAR; and seek public comment on whether the MY2022-2025 standards are appropriate under section 202(a). See 40 CFR section 86.1818-12(h). The time frame set forth in that rule specified that the Draft TAR be completed no later than November 15, 2017, and that the Final Determination be completed no later than April 1, 2018, or a period of only four and one-half months after the Draft TAR.

EPA has adhered to all of these requirements. The agencies (EPA, NHTSA, and CARB) prepared the Draft TAR, and sought and received substantial public comment thereon. EPA also considered all late comments on the Draft TAR. EPA carefully considered and responded in detail to all of the significant public comments as part of the record for the Proposed Determination. Part of the response was to make a number of changes urged by commenters. These included updating the baseline fleet to a MY2015 basis, better accounting for certain technologies in that baseline fleet, improving the vehicle classification structure to improve the resolution of cost-effectiveness estimates applied in the OMEGA model, updating effectiveness estimates for certain advanced transmission technologies, conducting additional sensitivity analyses (including those where certain advanced technologies are artificially constrained), and adding quality assurance checks of technology effectiveness into the ALPHA and Lumped Parameter Model. See Proposed Determination Appendix A at A-1 and A-2. EPA consulted with NHTSA and CARB as part of the process of developing the Proposed Determination. The Final Determination is based on an administrative record at the very least as robust as that for the 2012 FRM, including extensive state-of-the-art research projects conducted by EPA and consultants to both agencies, data and input from stakeholders, multiple rounds of public comment, information from technical conferences, published literature, and studies published by various organizations. EPA put primary emphasis on the many peer-reviewed studies, as well as on the National Academy of Sciences 2015 report on fuel economy technologies.

EPA has considered those comments that contend that the process the Administrator has followed with the Proposed Determination, especially regarding opportunities for stakeholders to provide meaningful public comment, is not in accord with the stakeholders' legitimate expectations. EPA believes that the comment period for the Proposed Determination is sufficient in light of the limited new data and information presented in that document as well as in the comments we received on the Draft TAR (which formed the technical underpinnings of the Proposed Determination). The Administrator has moved forward with the Proposed Determination based on an extensive technical record developed over several years of research, analysis, and public input, with the recognition that lead time and regulatory certainty are critical to the auto industry. Regarding pending industry studies that the Alliance believes could have improved EPA's analysis, having considered extensive input from industry and other sources and improved the quality of our technical understanding over several years, the sum of all of this information has reinforced our fundamental conclusions from the 2012 final rule that the standards are feasible and appropriate, and has even provided evidence to support the potential strengthening of the standards. The Administrator believes that the likelihood that new, unforeseen data or information of sufficient consequence to alter this determination might come to light in the near future is very small, and has concluded that the existing record fully supports a decision to move forward with the Final Determination.

Several commenters maintained that the Final Determination is a rulemaking, and therefore EPA must follow the rulemaking procedures in the Administrative Procedure Act ("APA"), or in section 307(d) of the Act, or both. These comments are mistaken. As noted in the Proposed and Final Determinations, this action is not a rulemaking. Rulemaking procedures are not legally required, and EPA has properly exercised its discretion to proceed by adjudication.

None of the EPA's own rules, nor the APA or the Clean Air Act (CAA), legally require the determination be made by rulemaking. First, EPA's own rules do not require rulemaking, unless EPA acts "to revise the standards" upon finding the existing standards "not appropriate." See 40 C.F.R. 86.1818-12(h). But here, EPA is finding the existing standards appropriate. Had EPA instead found the existing standards not appropriate, it would have initiated a rulemaking to revise them. See 77 FR 62784 (Oct. 15, 2012) (stating that if EPA concludes the standards are appropriate it will "announce that final decision and the basis for EPA's decision" and if EPA decides the standards are not appropriate, it will "initiate a rulemaking to adopt standards that are appropriate under section 202(a)").

Second, the APA does not require rulemaking. An APA rulemaking is defined as "formulating, amending, or repealing a rule." *Kennecott Utah Copper Corp. v. United States DOI*, 88 F.3d 1191, 1208 (1996) (citing 5 U.S.C. § 551(5)). By contrast, an agency's decision not to revise an existing rule after consideration of new information is not a rulemaking. See *National Mining Ass'n v. MSHA* ("*NMA*"), 599 F.3d 662, 670-71 (D.C. Cir. 2010); *ICORE v. FCC*, 985 F.2d 1075, 1082 (D.C. Cir. 1993). Here, as in *NMA* and *ICORE*, EPA considered new information and chose not to revise the existing standards. Thus, EPA was not required to, and did not, engage in rulemaking pursuant to the APA.

Third, the CAA does not require rulemaking. CAA § 307(d)(1)(K) imposes certain rulemaking procedures on the "promulgation or revision of regulations under section [202] and test procedures for new motor vehicles or engines under section [206], and the revision of a standard under section [202(a)(3)]." CAA § 202(a) also directs EPA to prescribe "by regulation" motor vehicle emission standards. But these directives are inapposite, because EPA is not promulgating a new emission standard (or test procedure) or revising an existing standard. Instead, EPA has decided not to revise an existing standard.

In the absence of any statutory or regulatory requirement to conduct rulemaking, "the choice between rulemaking and adjudication lies in the first instance within the agency's discretion." *POM Wonderful, LLC v. FTC*, 777 F.3d 478, 497 (2015) (citing *NLRB v. Bell Aerospace Co.*, 416 U.S. 267, 294 (1974)); see also *Ark. Power & Light Co. v. Interstate Commerce Com.*, 725 F.2d 716, 723 (1984) ("court will compel an agency to institute rulemaking proceedings only in extremely rare instances"); Richard J. Pierce, <u>Administrative Law Treatise</u> 503 (5th ed. 2010) ("On the federal level, and outside the unusual context of statutorily mandated exclusive reliance on rulemaking, all [judicial challenges to compel rulemaking over adjudication] have failed."). EPA has exercised its discretion to proceed by adjudication. The agency believes that doing so here is especially suitable for several independent reasons.

Here, EPA is not promulgating any new policies or standards. Rather, EPA has chosen to not revise its existing standards, after undertaking the process set forth in an existing rule. See 40 C.F.R. § 86.1818-12(h). Applying that rule's processes, EPA evaluated the factual record concerning existing standards, considering technical factors such as practicability, feasibility, technology effectiveness, impacts on the automobile industry and consumers, and safety. See *id.* § 86.1818-12(h)(1)(i)-(viii) (listing the factors). In order to do so, EPA compiled a thorough record, see *id.* § 86.1818-12(h)(2), and issued a Draft Technical Assessment Report, see *id.* § 86.1818-12(h)(3). And in this Final Determination, EPA has "set forth in detail the basis for the determination," *id.* § 86.1818-12(h)(4), and deemed the existing standards "appropriate," *id.* § 86.1818-12(h). Agencies regularly evaluate factual records through adjudication. See *POM Wonderful*, 777 F.3d at 497-98; *Safari Club Int'l v. Jewell*, 2016 U.S. Dist. LEXIS 136235, at *33-34 (D.D.C. Sept. 30, 2016); cf. also *Shays v. FEC*, 528 F.3d 914, 930 (D.C. Cir. 2008) (ruling that an agency "has authority to flesh out its rules through adjudications and advisory opinions" (citing *Shalala v. Guernsey Mem'l Hosp.*, 514 U.S. 87, 96 (1995))). Moreover, this action has no new future effects and disturbs no reliance interests. In some cases, rulemaking may be suitable where adjudication would unduly disturb reasonable reliance interests. See *Bell Aerospace*, 416 U.S. at 295. But this action does not change the existing standards; it creates no new rights, liabilities or rules of conduct different from those already established by the 2012 rule. Finally, EPA has historically not regarded analogous mid-course evaluations as legally requiring rulemaking. The agency routinely conducts mid-course evaluations of its standards, particularly those that have long lead times. In these prior cases, the agency did not find rulemaking legally required, even though as here, the actions closely reexamined facts relating to existing rules.[3] EPA continues this practice here, further justifying its exercise of discretion. See *Drake v. FAA*, 291 F.3d 59, 69 (2002) ("Where the agency's litigation position is consistent with its past statements and actions, there is good reason for the court to defer, for then the position seems simply to articulate an explanation of longstanding agency practice.").

EPA is not persuaded by the commenters' arguments to the contrary. Global Automakers and the Alliance commented that EPA must proceed by rulemaking because this action would have future effect on the industry and necessarily involve policy considerations. Not so. As the D.C. Circuit has repeatedly held, "the fact that an order rendered in an adjudication may affect agency policy and have general prospective application does not make it rulemaking subject to APA section 553 notice and comment." *POM Wonderful*, 777 F.3d at 497 (citing *Conference Grp., LLC v. FCC*, 720 F.3d 957, 966 (D.C. Cir. 2013)). Indeed, "adjudicated cases may and do serve as vehicles for the formulation of agency policies, which are applied and announced therein, and . . . such cases generally provide a guide to action that the agency may be expected to take in future cases." *Bell Aerospace*, 416 U.S. at 294 (citing *NLRB v. Wyman-Gordon Co.*, 394 U.S.

[3] For example, in the final rule for heavy-duty engine standards (66 FR 5063, January 18, 2001), EPA announced regular biennial reviews of the status of the key emission control technology. EPA subsequently issued those reviews in 2002 and 2004, without going through rulemaking. See EPA Report 420-R-02-016; EPA Report 420-R-04-004. Or for instance, in the final rule for the Nonroad Tier 3 standards (63 FR 56983, Oct 23, 1998), EPA committed to reviewing the feasibility of the standards by 2001 and to adjust them by rulemaking if necessary. In 2001, without engaging in rulemaking, EPA published a report (see EPA Report 420-R-01-052) accepted comments, and concluded in a memorandum placed in the docket that the standards remained technologically feasible (Memorandum: "Comments On Nonroad Diesel Emissions Standards: Staff Technical Paper," from Chet France to Margo Oge, June 4, 2002).

759, 765-66 (1969)). And an agency may in its "very broad discretion" use adjudication to formulate orders broadly applicable to an entire industry. *Qwest Servs. Corp. v. FCC*, 509 F.3d 531, 536 (D.C. Cir. 2007).

EPA agrees that this action, like virtually any administrative action, may implicate some policy considerations relevant to the industry. The determination that the existing standards are appropriate, however, does not alter agency policy; the policies of the 2012 rule remain in place. And as already noted, this action does not change the existing legal rights and obligations of regulated parties.[4]

The Alliance additionally commented that EPA's decision to provide public notice and comment necessarily transforms this action into a rulemaking. The Alliance cites no legal authority for this claim, and EPA is unaware of any. To the contrary, "[a]gencies are free to grant additional procedural rights in the exercise of their discretion." *Vt. Yankee Nuclear Power Corp. v. Nat. Res. Def. Council, Inc.*, 435 U.S. 519, 524 (1978). EPA is thus free to proceed by adjudication with enhanced procedures, such as notice and opportunity to comment.

The Alliance further commented that EPA must proceed by rulemaking because EPA has stated that the authority for the MTE is found in CAA 202(a), and because EPA has "reopened" the prior rule and its record, citing cases like *General Motors Corp. v. EPA*, 363 F.3d 442, 449-50 (D.C. Cir. 2004) and *National Mining Association v. Department of Interior*, 70 F.3d 1345, 1352 (D.C. Cir. 1995). In the alternative, the Alliance argues further that the Proposed (and now Final) Determination constitutes a reconsideration of the MY2022-2025 standards under section 307(d)(7)(B) of the Act.

These arguments fundamentally mistake the nature of the MTE. EPA established the MTE process by regulation. See 40 CFR 86.1818-12(h). EPA continues to believe the authority for that regulation derives from the authority to establish appropriate standards pursuant to CAA section 202. See 77 FR at 62786. That regulation requires the Administrator to make a determination whether the MY2022-2025 standards are appropriate, after an opportunity for public comment. See 40 CFR 86.1818-12(h). The regulation further requires that *if* the Administrator determines the standards are not appropriate, then the Administrator will initiate a rulemaking to revise the standards. Id.

Thus, the Final Determination is not "reopening" or "reconsidering" the 2012 rule. Rather, the Administrator is undertaking an examination of the factual record currently before her *pursuant* to the 2012 rule, and that rule does not require any further rulemaking when she determines that the standards are appropriate. In fact, the commenter acknowledges that in promulgating the 2012 rule EPA rejected the argument that the MTE would constitute a "reconsideration" of the rule under CAA 307(d). See 77 FR at 62786. Section 307(d)(7)(B) applies to situations where EPA is required to reconsider a rule on the basis of new information raised by a petitioner to the agency which information could not have been available during the rulemaking. Here EPA is carrying out the provisions of the rule, by assessing the appropriateness of the standards. Section 307(d)(7)(B) is entirely inapplicable in these circumstances.

[4] As noted above, although not relevant here, agencies are generally permitted to change policy, with prospective effect on regulated entities, through adjudication.

Moreover, the fact that the agency reviewed new factual information as part of the determination does not itself trigger any requirement to undertake rulemaking. To the contrary, where the agency decides not to revise its existing standards, it need not proceed by rulemaking, even if it considers new information. See *NMA*, 599 F.3d at 670-71; *ICORE*, 985 F.2d at 1082. In both *NMA* and *ICORE,* as here, the agency expressly considered substantial new information in issuing the challenged determinations. Nonetheless, in both cases, the court upheld the agency's choice to not proceed by rulemaking. See *NMA*, 599 F.3d at 670-71; *ICORE*, 985 F.2d at 1082.

It is also worth noting that the case law on "reopening" rules is further inapplicable because it simply addresses when a court may consider a challenge to a long-standing rule that would otherwise be time-barred. Relatedly, Global Automakers commented that EPA must institute rulemaking because of the "substance of what the [agency] has purported to do and has done," citing *Center for Auto Safety v. National Highway Traffic Safety Administration*, 710 F.2d 842, 846 (1983).

These authorities are inapposite. They address whether a court has jurisdiction to review agency action, not whether an agency must proceed by rulemaking or adjudication.[5] Here, EPA has stated that the Final Determination is a reviewable, final agency action. See 77 FR at 62784. The question here is not whether a court would have power to hear a petition for review, but whether EPA is required to follow rulemaking procedures. The authorities cited by commenters do not address this issue.

Commenters also stated that the Proposed and Final Determination should have been submitted to the Office of Management and Budget pursuant to Executive Order (EO) 12866, arguing that section 6 of that Executive Order requires review of "significant regulatory action[s]," meaning actions "likely to result in a rule that may have an annual effect on the economy of $100 million or more." The Final Determination is not an action subject to EO 12866 review and has no economic effect. It determines that standards previously promulgated in a final rule (which was subject to review per the Executive Order) remain appropriate, and leaves the current regulatory status-quo unaltered.

[5] Moreover, as noted above, EPA has not reopened the 2012 rule—it has fulfilled its obligations under the 2012 rule and concluded that the standards are appropriate.

Chapter 2: Technology Assessment

2.1 Effectiveness Assessment: General Comments, Technology Packages, Penetrations, and Sufficiency of Non-Electrified Technologies

Summary of Comments on the Draft TAR addressed in the Proposed Determination

Some comments received on the Draft TAR were critical of EPA's assessment of technology effectiveness and its compliance projections, while others were supportive. Upon examination of specific comments to this effect, both broadly and with respect to specific technologies examined throughout the Proposed Determination and the Technical Support Document (TSD), EPA concluded in its assessment that the effectiveness values developed for the Draft TAR were largely accurate representations of benefits achievable by manufacturers within the MY2022-2025 time frame. EPA also noted that this was not to state or imply that every manufacturer that had added a technology had already achieved the effectiveness estimated in the Draft TAR. Some technologies that are currently in their first or second design iteration may improve in effectiveness in successive iterations. One example provided was the emerging use of integrated and cooled exhaust manifolds and the resulting improved effectiveness from turbo-charged downsized engines. Additionally, we noted that some manufacturers that have adopted technology may have used some of the benefit to improve other vehicle attributes, rather than solely to improve fuel economy;[6] but when these technologies are combined with the sole intent of improving vehicle efficiency, our analyses continue to show that significant improvements from the baseline fleets are broadly achievable using conventional powertrains (see Section 2.1 of the TSD at p. 2-1 to 2-2).

Some auto industry commenters stated generally that the EPA models and/or effectiveness assumptions are overly optimistic, while other commenters recommended higher technology effectiveness values than we estimated in the Draft TAR. In some cases, the commenters either did not provide any supporting evidence, or provided evidence that was incomplete, not applicable, or not relevant to an assessment of the cost, effectiveness, and implementation feasibility in MYs 2022-2025. In particular, the conclusion drawn by the Alliance of Automobile Manufacturers that "MY2021 and MY2025 targets cannot be met with the suite of technologies at the deployment rates projected by the Agencies in the 2012 FRM" is based on the premise that the only possible technology available in MY2025 will be represented by technology already contained in the Draft TAR's MY2014 baseline fleet, and that technology will not improve in efficiency. See TSD App. A. In response, EPA disagreed with this assertion, noting that it is not plausible that the best gasoline powertrain efficiencies of today represent the limit of achievable efficiencies in the future. Id. at A.1. Even setting aside the assumption that the best available technologies today will undergo no improvement in future years (a premise the auto industry has disproved time and again), the methodology used in the Alliance-contracted study (which was not peer reviewed) does not even allow for the recombination of existing technologies, and thus severely and unduly limits potential effectiveness increases obtainable by MY2025. Id. at A.2. Further, EPA disagreed with this assumption that the only technology combinations available in MY2025 are those that are present in the MY2014 fleet. EPA noted that events had already

[6] For example, the DeFour Group analysis cited by the Alliance in its comments on the Proposed Determination alluded to manufacturers of strong hybrids allocating fuel efficiency gains to improved performance or towing capacity rather than fuel economy (DeFour Group attachment to the Alliance comments, p. 14).

disproven this assumption and provided, as one specific example, a Ford-introduced 10-speed automatic transmission on the MY2017 F150 paired with a turbocharged downsized engine which represents a technology combination that was not previously available and was therefore not considered (and would be deemed impossible) by the Alliance-contracted study. Id. In contrast, EPA's Proposed Determination projections of effectiveness through MY2025 included technology packages that are achievable and cost-effective, but did not exist in the MY2014 fleet. For example, a 24 bar turbocharged downsized engine with cooled EGR, or a high compression ratio Atkinson cycle engine with cylinder deactivation and cooled EGR paired with an efficient high speed, high efficiency, high ratio spread transmission. EPA's approach for evaluating technology effectiveness was and still is based on detailed data for individual technologies and physics-based vehicle modeling of combinations of technologies. In the Proposed Determination, EPA stated its assessment that these particular comments by the Alliance with respect to future technology effectiveness were drawn from an approach that was overly simplistic, lacked rigor, and therefore did not call into question EPA's determination that the technology assessment supported the Proposed Determination that the MY2022-2025 standards remain appropriate. EPA’s detailed response to the Alliance-contracted study is found in the TSD (Chapter 2.3.3 and Appendix A).

In comments on the Draft TAR, several commenters, including many NGOs, state and local government organizations, and consumer groups, supported EPA's assessment in the Draft TAR as a robust assessment of technology availability showing multiple cost-effective paths (compliance paths more cost-effective than those considered by the agencies in the 2012 FRM) to comply with the 2025 standards. Some groups believed our assessment to be overly conservative; for example, the International Council on Clean Transportation (ICCT) expressed the view that there are some key areas where the Draft TAR analysis "is still somewhat behind what is already happening in the market," and the American Council for an Energy-Efficient Economy (ACEEE) stated that additional technology options are “developing rapidly and are likely to result in multiple options at least as cost effective as those represented in the agencies’ analysis.” Both ICCT and ACEEE cited examples of technologies that EPA did not model, like e-boost, variable compression ratio, and dynamic cylinder deactivation, which they stated are currently undergoing active development and are likely to contribute to cost-effective paths for compliance in the MY2022-2025 time frame.

Regarding the Draft TAR’s estimated penetration rates of electrified vehicle technologies, the Alliance, Global Automakers, and several individual automakers commented that more strong hybrids and electric vehicles would be needed to achieve the standards (MY2025 in particular) than projected by the agencies. This is the corollary to the comment summarized above that EPA was overly optimistic in assessing efficiencies and availability of advanced gasoline engine and other technologies. As described above, EPA responded that the premise underlying this comment was unfounded, undocumented, and already inconsistent with market developments. Thus, EPA’s initial response on the issue of amount of electrification needed to comply with the MY2022-2025 standards continued to be that the standards are achievable using minimal amounts of strong hybrid and all-electric vehicles.

Building on their premise that more electrification would be needed (which EPA did not accept), the various auto industry commenters went on to state that sales of hybrid (HEV) and plug-in electric vehicles (PEV) have fallen due to current low gasoline prices. With gasoline prices not expected to rise rapidly in the time frame of the Midterm Evaluation, they were concerned that they will not be able to sell the vehicles they assert to be needed to meet the standards. In contrast, comments by Tesla Motors, the International Council on Clean Transportation (ICCT), Nextgen Climate America, Consumer Federation of America (CFA), and Faraday Future suggested that consumer acceptance of electrified vehicles is rising rapidly, especially with longer-range PEVs becoming less expensive. Tesla suggested that EPA should increase the stringency of the standards to encourage both advanced gasoline technologies and PEVs. Faraday Future and Consumer Federation of America cited survey evidence that interest is growing in PEVs, especially among young people. ICCT pointed out that the prospects for PEVs have improved in recent years, and that many companies are deploying this technology. Nextgen Climate America said that PEVs can offer greater benefits than assumed in the Draft TAR. The National Association of Clean Air Agencies also commented, pointing to rapid growth in sales of hybrid and electric vehicles in the states that have adopted California's Zero Emission Vehicle program, as well as other states. Given that EPA identified multiple compliance pathways, all only minimally dependent on use of PEVs, EPA did not consider this debate as weighing significantly on the subject of the Proposed Determination, viz. whether the standards remain appropriate (See Section B.1.5.2 of the Proposed Determination Appendix and Sections B.1.5 and C.1.2 of the Proposed Determination Appendix).

OEM commenters also aimed criticism at differences in projected penetrations of individual technologies between the Draft TAR and the 2012 FRM, characterizing these differences as evidence that the agencies' analysis approach was unsound. In response, EPA pointed out that these differences are not evidence of a flawed analysis but are a natural result of the Draft TAR having recognized and included innovations and improved efficiencies that occurred since the 2012 FRM, the very sorts of improvements that the Alliance contractor report assumed would not occur between now and 2025. See Proposed Determination at p. 24. In addition, the technologies reflected in the Draft TAR and Proposed Determination analyses reflect many of the technology changes that have been introduced in the fleet since the 2012 FRM. Thus, EPA would be remiss to not consider these technologies within the context of the MTE. The 2015 NAS report also recognized these important emerging and changing technologies, such as Atkinson cycle engines and CVTs, and recommended that the agencies consider these technologies in their future analyses. EPA thus disagreed that such differences in projected technology penetrations indicate in any way that the analysis and analytic approach were unsound. On the contrary, the incorporation of new technologies and unforeseen applications since the 2012 FRM would necessarily influence the cost-effective pathway modeled by EPA. Id. at p. 25. For example, the application of direct injection Atkinson cycle engines in non-hybrids, greater penetration of continuously variable transmissions (CVTs), and 48-volt mild hybridization have all influenced projected technology penetrations, as have developments in downsized turbo-charged engines, cylinder deactivation, and electrification. EPA also noted the consistently low level of strong electrification projected in the 2010 TAR, 2011 NPRM, 2012 FRM, and 2016 Draft TAR, as further corroborated by the 2015 National Academy of Sciences (NAS) study. This consistency has persisted even as EPA's technology assessment and compliance analysis has undergone many updates and improved in its precision over the past six years, further supporting EPA's determination that the MY2022-2025 standards remain appropriate. Id.

Commenters on the Draft TAR also asserted that differences between the 2012 FRM and Draft TAR with respect to the technologies considered and their projected penetrations suggest that the analyses were flawed. For example, the Global Automakers and its members commented that "the agencies should investigate and document why their previous predictions (from the FRM) were inaccurate." EPA responded that, in fact, if the differences were inaccuracies, they only represented the failure to anticipate the success with which the industry has innovated to increase efficiencies in the intervening years between the FRM and Draft TAR. EPA did not agree that variations in modeled technology penetrations from the FRM to the Draft TAR were an indication that the analysis and analytic approach were unsound. EPA further pointed out that incorporating new technologies and unforeseen applications that had emerged since the 2012 FRM would be expected to have an impact on the penetrations of technologies in the cost-effective pathway modeled by OMEGA. EPA cited examples such as the application of direct injection Atkinson cycle engines in non-hybrids, greater penetration of continuously variable transmissions (CVT), and 48-volt mild hybridization which would all tend to influence projected technology penetrations. EPA also noted the consistency with which only low levels of strong electrification were projected in the 2010 TAR, the 2011 NPRM, the 2012 FRM, the 2016 TAR and the Proposed Determination as evidence that the analyses were robust, and further cited the 2015 National Academy of Sciences (NAS) study which also found that the 2025 standards would be achieved largely through improvements to gasoline technologies without extensive electrification.

Regarding the projected penetration of higher compression ratio, naturally aspirated gasoline engines (Atkinson 2), the Alliance stated in their comments on the Draft TAR that they did not believe that the projected market penetration of Atkinson 2 technology (at over 40 percent) was likely or feasible. EPA noted (in part) that the Proposed Determination analysis projected a reduced penetration of Atkinson 2 (at 27 percent), and that this reduction was the result of refinements in EPA's effectiveness modeling that better reflect the relative improvements allocated to advanced engines and transmissions in powertrain packages. See for example Section IV.A.3 of the Proposed Determination at p. 39, and Section C.1.1.3.2 of the Proposed Determination Appendix at p. A-132. EPA also presented sensitivity analyses, one of which artificially constrained Atkinson 2 technology to 10 percent penetration. This sensitivity demonstrated that cost-effective compliance paths using primarily other advanced gasoline engine technologies continue to exist even under this scenario, at only modestly increased costs (see Section C.1.2.1.4 of the Proposed Determination Appendix at p. A-144 and p. A-147). Significantly, even those increased cost estimates remain lower than the agencies projected in the 2012 FRM, which the agencies have already evaluated as being reasonable. EPA provided rationale for the feasibility of Atkinson 2 including responses to lead time arguments in Section A.2.3.1 of the Proposed Determination Appendix at p. A-7 and in Chapter 2.3.4.1.8.3 of the TSD at p. 2-308 to 2-311. Comments relating to lead time for deployment of the Atkinson 2 technology are also discussed in Chapters 2.5.1 and 4.3 of this RTC document.

<u>Summary and Response to Comments on the Proposed Determination</u>

In comments on the Proposed Determination, many NGOs repeated their disagreement with the prevailing stance of many of the auto industry commenters that the standards are not achievable with advanced gasoline technologies and would require much higher levels of electrification than EPA projects. For example, ICCT supported EPA's Proposed Determination but continues to believe that EPA's analysis utilized conservative assumptions for the cost and effectiveness of many technologies. In addition, the Environmental Defense Fund (EDF) commented that more stringent standards for MY2022-2025 are feasible, and shared an analysis to support this view. In order to assess the cost and technology penetration implications of setting more stringent standards, EDF's analysis, conducted using EPA's OMEGA model, includes four scenarios that are 10, 20, 30, and 40 g/mi more stringent than the current MY2025 target of 173 g/mi. EDF noted that the 20 and 30 g/mi more-stringent scenarios demonstrated that the standards could be met cost-effectively with the same advanced technology pathways projected to be utilized in EPA's analysis of the existing MY2022-2025 standards, and with very low levels of strong hybrids and electric vehicles. This analysis also indicated that the lifetime fuel savings benefits to consumers (assuming AEO 2016 reference case fuel prices, as in EPA's analysis) would more than outweigh the projected increase in vehicle cost. EPA appreciates this informative analysis.

In contrast, some industry commenters repeated the suggestion that variations in projected technology penetrations were evidence that the analyses were unsound.

Global Automakers, The Alliance, and Toyota stated that it was unclear how EPA arrived at significant changes in technology penetrations between the two analyses, with specific reference to the reduction in projected Atkinson 2 engine penetration (from 44 percent to 27 percent).

In response, as mentioned above, EPA noted in the Proposed Determination that this reduction was in part the result of refinements in EPA's effectiveness modeling that better reflect the relative improvements allocated to advanced engines and transmissions in powertrain packages. Another factor was the adoption of a modeled increase in engine displacement of 5 percent to ensure that acceleration performance is not degraded due to knock protection measures when using regular grade gasoline. This change in EPA's assessment for Atkinson technology was in direct response to comments received on the Draft TAR. (See for example Section IV.A.3 of the Proposed Determination at p. 39, Section C.1.1.3.2 of the Proposed Determination Appendix at p. A-132, and Chapter 2.3.4.1.8.1 of the Technical Support Document at p. 2-298). The change is also discussed in Chapter 2.8 in the discussion of OMEGA outputs where more context is provided.

BMW stated that EPA underestimated the current penetration of advanced powertrain and lightweighting in its fleet, saying that BMW has already included these technologies in current vehicles, and that EPA overestimates the potential for further improvements, leading to the need for higher levels of electrification, especially in light of lower fuel prices than anticipated in the 2012 final rule. BMW's general comment is substantively the same as the comments on the need for greater electrification that the Alliance and other manufacturers made on the Draft TAR, and our response to those comments in the Proposed Determination applies to these comments as well. Regarding the specific example BMW gives of their current technology offerings, we believe we have accurately incorporated BMW's situation into our fleetwide modeling.

Global Automakers referred to the changes in Atkinson 2 penetration and several individual manufacturer's technology costs from the Draft TAR to the Proposed Determination as evidence of general volatility in EPA's model, positing that EPA had made "significant revisions in the course of a few months" and "[t]hese radical changes from one analysis to the other belie the claim … that there was a 'Robust Technical Analysis'…" EPA disagrees, noting that contrary to the assertion of modeling volatility, EPA's assumptions of technology package cost-effectiveness considered in the OMEGA model have remained highly stable between the Draft TAR and Proposed Determination assessments.

While the technology types considered and their projected penetrations have indeed changed over the time span between the 2012 FRM, Draft TAR, and Proposed Determination, these changes are largely due to the innovation of the automotive industry being reflected in our updated analyses. Furthermore, even as these technologies and penetrations have changed, the stability of EPA's estimated costs for complying with the standards support the conclusion that there are several viable cost-effective alternative pathways to meeting the MY2025 standards and that substantial levels of electrification will not be required. For example, transmission technology is one example of how competing technologies may evolve due to innovation to produce parallel options with little difference in cost or effectiveness. While the compliance costs will tend to be stable due to competition between multiple similarly cost-effective technologies, when a minor change in cost-effectiveness for one technology does occur (e.g., due to innovation), the projected penetration of the various competing technologies can change, in some case significantly. In the 2012 FRM, based in part on input from the auto industry and other stakeholders, EPA's assessment was that dual clutch transmissions (DCTs) would provide a better opportunity for significant improvements in vehicle efficiency than continuously variable transmissions (CVTs), due to indications that CVTs demonstrated characteristics that were unacceptable to U.S. consumers. However, since the 2012 FRM, it became clear that early implementations of DCTs were experiencing some consumer resistance, while CVTs were becoming well accepted in the market due to ongoing improvements (for example, improvements to control strategies, such as the implementation of indexed shifting to simulate the feel of a conventional automatic transmission). As a result, penetration of CVTs had become much greater than originally expected. In addition, improvements have been made in each type of automatic transmission such that the relative difference in efficiency between transmission architectures is rapidly diminishing. EPA believes that the changes reflected in each of EPA's analyses are the natural result of our representing in these analyses the continuing innovation in the light-duty market, and are not indicative of volatility, instability, or unsoundness as some commenters suggest.

Further, an examination of the cost-minimizing technology pathways also supports the stability of the assessments. Figure 2-1 through Figure 2-5 below show the curves that define the cost-minimizing technology package at each level of effectiveness ('frontier curves') for small car, standard car, cross-over utility, sport utility, and pickup truck vehicle classes. In these Figures, the technology cost-effectiveness estimated by EPA is shown to have generally improved in the Draft TAR and Proposed Determination (lowered frontier curves) relative to the FRM assessment, consistent with lower cost and/or higher effectiveness values that were identified in some cases by EPA when considering additional technologies and updated information in these most recent assessments. We note in these figures that conventional, non-electrified gasoline technology packages reside primarily in the region below 45 percent effectiveness, which is also the range of effectiveness values that will generally enable manufacturers to achieve the 2022-2025 standards. Within this critical range of effectiveness values, it can be seen that technology cost-effectiveness has remained within a narrow band between the Draft TAR and Proposed Determination – a finding that directly contradicts the commenter's assertion of "radical changes" that would call into question EPA's conclusions regarding the sufficiency of conventional non-electrified technologies. On the contrary, the consistency between the Draft TAR and Proposed Determination frontier curves shown in Figure 2-1 through Figure 2-5 is a direct indication of the general stability in EPA's modeling.

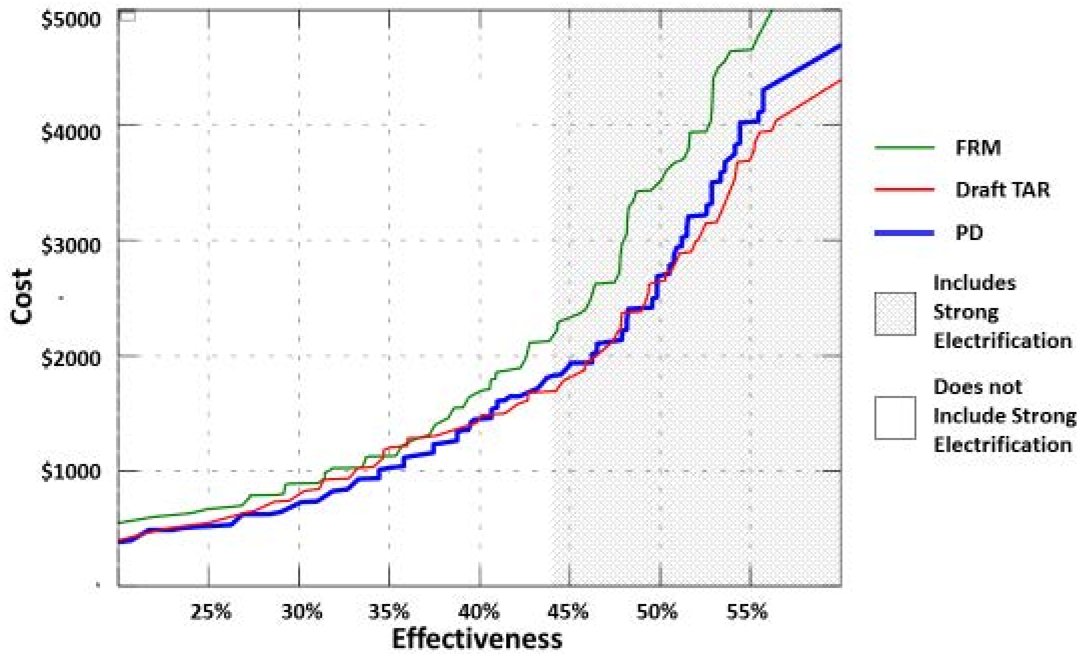


Figure 2-1 Most Cost-Effective Technology Packages Considered by EPA: Vehicle Type 1, Low Power-to-Weight, Low Road Load Vehicles (Small Car in Draft TAR) w/ I4 DOHC

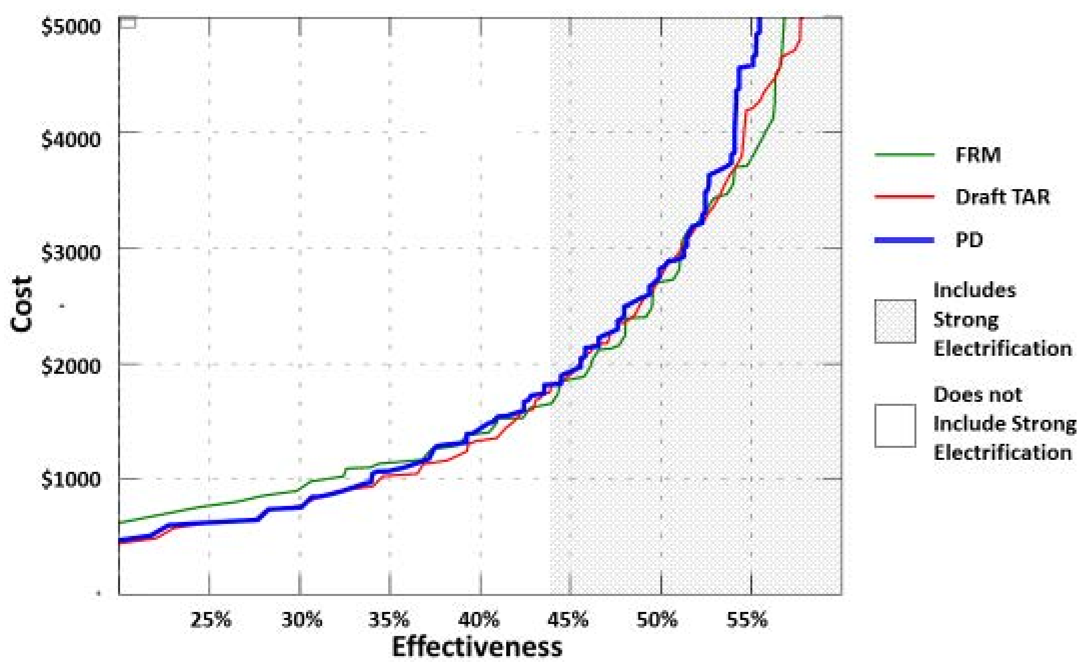


Figure 2-2 Most Cost-Effective Technology Packages Considered by EPA: Vehicle Type 13, Mid Power-to-Weight, Low Road Load Vehicles (Standard Car, Vehicle Type 3 in Draft TAR) w/ V6 DOHC

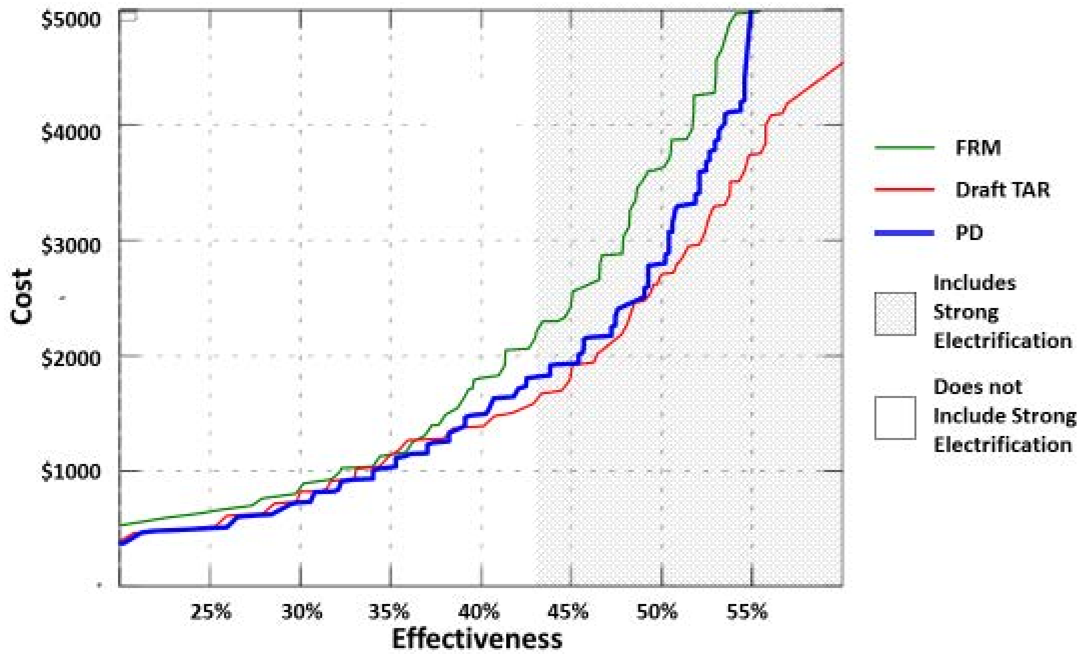


Figure 2-3 Most Cost-Effective Technology Packages Considered by EPA: Vehicle Type 4, Low Power-to-Weight, High Road Load Vehicles (Small MPV, Vehicle Type 7 in Draft TAR) w/ I4 DOHC

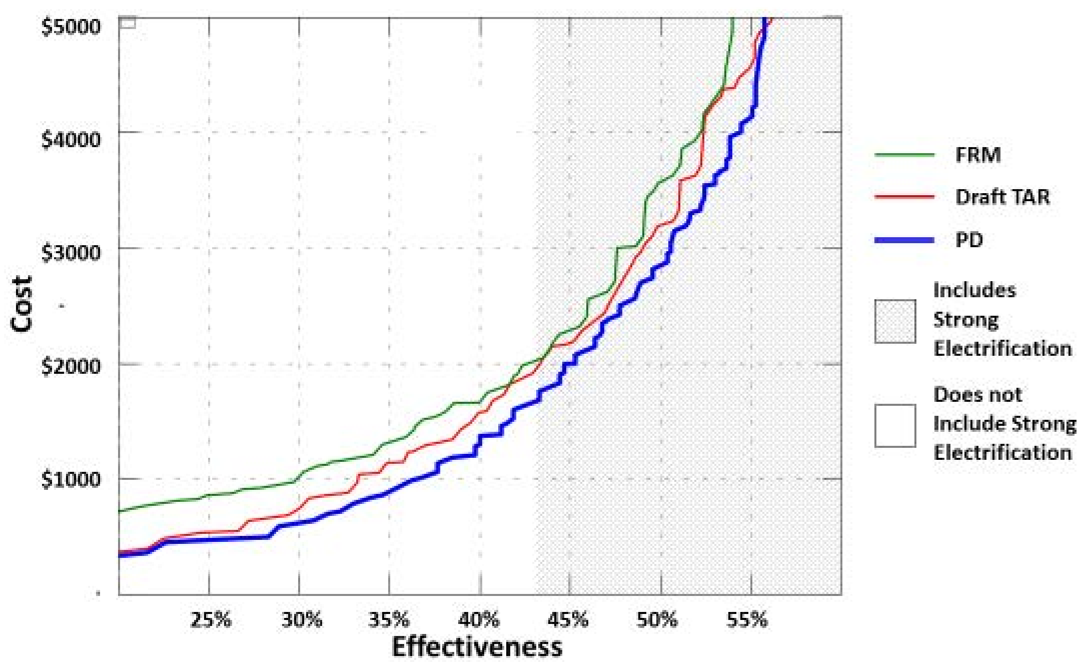


Figure 2-4 Most Cost-Effective Technology Packages Considered by EPA: Vehicle Type 11, Mid Power-to-Weight, High Road Load Vehicles (Large MPV, Vehicle Type 9 in Draft TAR) w/ V6 SOHC

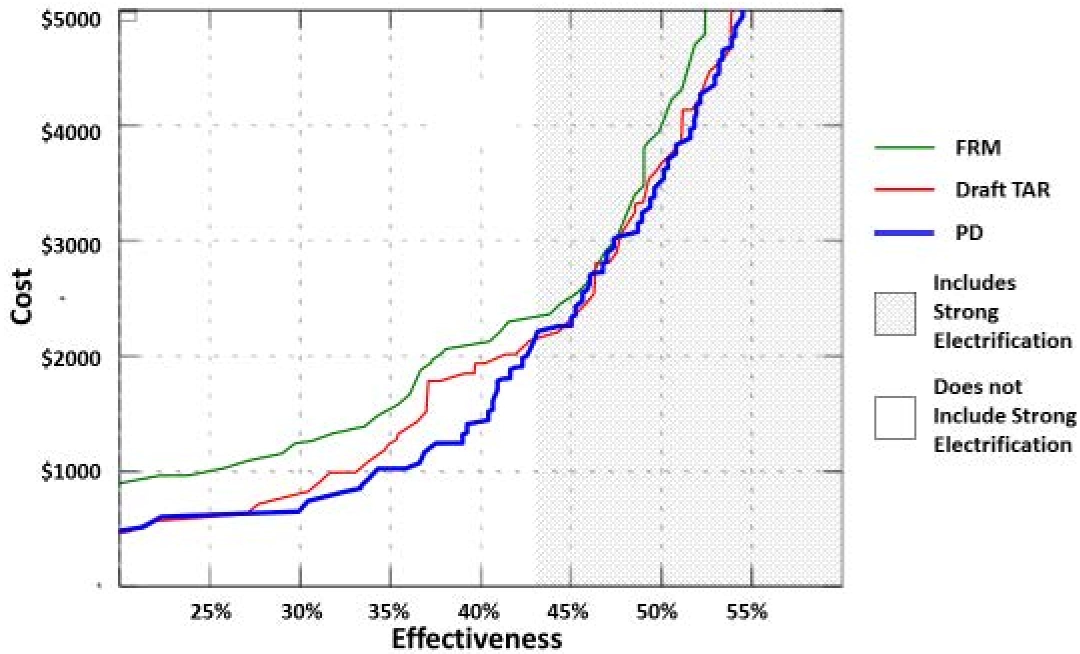


Figure 2-5 Most Cost-Effective Technology Packages Considered by EPA: Vehicle Type 29, Pickup Trucks (Vehicle Type 16 in Draft TAR) w/ V8 DOHC

One of the main arguments in the comments received on the Draft TAR for why the standards would have an adverse impact on the industry was reiterated by several manufacturers in comments on the Proposed Determination; that the standards, although achievable, would require manufacturers to adopt extensive electrification, resulting in more expensive vehicles – and emerging technologies – which commenters assert consumers will be reluctant to purchase. As in comments on the Draft TAR, the conclusion regarding the extent of electrification required followed logically, in the view of the commenters, from their comments reiterating that EPA was overly optimistic in assessing efficiencies and availability of advanced gasoline engine and other conventional technologies. A few manufacturers shared confidential business information illustrating technology walks, which show the cumulative effects of the application of various technologies applied to a given vehicle model. However, while the technology walks provided include some of the same advanced technologies considered by EPA, none of them included a fuller range of conventional technologies in the combinations described in the Proposed (and Final) Determination. Some are missing very reasonable vehicle technologies, some are missing very reasonable engine technologies, and some are missing very reasonable transmission technologies. Because the example technology walks supplied by the manufacturers don't include all technologies in the appropriate combinations, and in some cases don't include the appropriate credit values, the examples show a shortfall in achieving the MY2025 CO_2 targets (as would be expected) of about 20-40 g/mi depending on the vehicle. This resulting gap between the EPA and manufacturer-supplied projections would be eliminated if a broader set of the available technologies described in the Proposed and Final Determination were included in their analysis and appropriate credit values were used.

In response, EPA's conclusion that the standards can be achieved using relatively small penetration rates of strong hybrid and all-electric vehicles has been reinforced in the Draft TAR and Proposed Determination assessments with the incorporation of information from the most recent market implementations of technologies, additional benchmarking data of recent production vehicles, extensive reviews of the literature, and refined modeling approaches. This conclusion is also supported by the 2015 NAS study and a number of sensitivity analyses conducted by EPA that assumed, among other things, significantly less use of the Atkinson engine technology. See Table ES-1 and the Proposed Determination Section IV.A.3 and Appendix C.1. Thus, EPA's response on the issue of the sufficiency of conventional gasoline technologies and the amount of electrification needed to comply with the MY2022-2025 standards remains that the standards are achievable using very low amounts of strong hybrid and all-electric vehicles.

While EPA's assessment in the Proposed Determination of non-electrified technologies reflect a number of updates since the 2012 FRM and the Draft TAR, EPA incorporated the details regarding new technology in two different ways. Some technology was updated and fully modeled and simulated. Other technology changes were identified as supporting of our conclusions but not fully simulated. For example, while EPA cited information that was published by manufacturers for several new highly efficient engines that had recently entered production or were production ready, these data (which included engine maps) were not included directly in EPA's effectiveness modeling. In response to stakeholder comments on the Proposed Determination regarding EPA's effectiveness estimates for advanced gasoline engine technologies, EPA has utilized this publicly available information to further corroborate our assessment regarding the sufficiency of conventional gasoline technologies by showing that vehicles equipped with these existing gasoline engine technologies, along with improved transmissions and road load reduction technologies, can support compliance with the MY2025 targets. The process used by EPA was very similar to that described in a paper published in 2016.[7]

For these technology walks, EPA first selected five production vehicles each from two full-line manufacturers, which are representative of important vehicle classes: small car, midsize car, cross-over utility vehicle, sport-utility vehicle, and pickup truck. The vehicle characteristics were drawn from the MY2015 EPA Test Car List, to ensure that emissions values, test weights, and road load coefficients were representative of actual tested vehicles without the application of any adjustment or averaging as may be the case for certification values. The characteristics of these tested vehicles are described in Table 2-1.

[7] Kargul, J., Moskalik, A., Barba, D., Newman, K. et al., "Estimating GHG Reduction from Combinations of Current Best-Available and Future Powertrain and Vehicle Technologies for a Midsized Car Using EPA's ALPHA Model," SAE Technical Paper 2016-01-0910, 2016, doi:10.4271/2016-01-0910.

Table 2-1 Technology Walks with Existing Engines: Baseline Vehicle Specifications

	MY 2015 Actual Vehicles					
	Footprint (sq. ft.)	ETW (lbs.)	A Coeff. (lbf)	B Coeff. (lbf/mph)	C Coeff. (lbf/mph2)	Rated Horse Power
Corolla	44.1	3125	29.834	-0.08450	0.021121	132
Camry	47.2	3500	27.232	0.04319	0.019374	178
RAV4 AWD	44.9	3875	33.417	0.07314	0.026719	176
Highlander AWD	49.0	4750	39.939	0.04131	0.030299	270
Tundra AWD	68.7	5500	37.347	0.63046	0.039122	381
Fiesta	40.8	2875	22.880	0.25500	0.019160	120
Fusion	49.0	3750	18.880	0.30750	0.015990	169
Escape AWD	45.6	4000	25.100	0.42490	0.023360	173
Explorer AWD	52.5	5000	36.190	0.84250	0.022530	290
F150 AWD	68.1	5250	31.040	0.35380	0.036860	365

Next, using the ALPHA model, EPA constructed two independent technology walks for each of the vehicles with characteristics described in Table 2-1, using data recently published by manufacturers for two highly efficient gasoline engines. The first technology walk series is based on Toyota's published efficiency map for a 2.5L Atkinson cycle engine with cooled EGR.[8] The second technology walk series is based on the published map of Honda's 1.5L four-cylinder turbo engine.[9]

Each technology walk begins with the MY2015 vehicle and sweeps through a series of five different technology packages:

- The initial technology package in each technology walk includes the efficient gasoline engine (either the Toyota or the Honda), an existing high ratio spread transmission (the EPA-benchmarked MY2014 8-speed, or TRX21), and stop-start technology if not already present on the baseline vehicle.
- In the next technology package, the automatic transmission was improved to reflect future efficiency improvements (TRX22) and improved accessory loads, reduced from 390 to 290 watts consistent with the approach used in the Proposed Determination assessment.

[8] Toyota: Eiji Murase and Rio Shimizu, "Innovative Gasoline Combustion Concepts for Toyota New Global Architecture," 25th Aachen Colloquium Automobile and Engine Technology 2016.

[9] Honda: Wada, Y., Nakano, K., Mochizuki, K., and Hata, R., "Development of a New 1.5L I4 Turbocharged Gasoline Direct Injection Engine," SAE Technical Paper 2016-01-1020, 2016, doi:10.4271/2016-01-1020. (supplemented with data publicly available during the 2016 SAE World Congress).

- In the final three technology packages of the technology walks, increasing levels of aerodynamic, tire, and mass road load improvements are applied from 10 percent in the low load reduction case to 20 percent in the high load reduction case.[10]

The modeled results of the technology walks are presented below. Table 2-2 shows tailpipe CO_2 values of the modeled packages for the 10 modeled vehicles, while Table 2-3 shows the difference between these tailpipe CO_2 values and the footprint target values for the MY2025 standards. Importantly, Table 2-3 shows that 6 of the 10 vehicles are able to meet or exceed their respective MY2025 target values with only low or moderate levels of load reduction based on the Toyota engine, while 7 of the 10 vehicles are able to meet or exceed target values with moderate or high levels of road load reduction based on the Honda engine.

Overall, these findings corroborate EPA's conclusion that the standards are achievable with primarily non-electrified technologies. First, the fact that roughly half of the vehicles in these tech walks are able to generate credits in MY2025 using current engine technology and moderate road load reduction is indicative of a favorable compliance scenario with fleet average standards such as these, since not every vehicle in a manufacturer's fleet would need to meet its individual footprint target. Second, due to a number of conservative assumptions made when conducting this technology walk analysis, the opportunity for conventional technologies to contribute to achieving the standards will likely be even greater than indicated by these results. The first of these conservative assumptions is the effective double counting of transmission neutral-drag losses. Specifically, since EPA had not quantified these losses for each specific vehicle, the road load coefficients were not adjusted, resulting in an average 3 percent greater CO_2 value for the 10 modeled baseline vehicles than the actual tested vehicles; an overestimation that is likely propagated to some extent through the subsequent technology packages in each techwalk. Additional conservative assumptions made by EPA in these techwalks include the assumption that there will be no further improvements in engine technologies beyond these two existing engines, and the lack of consideration of off-cycle credits beyond the stop-start credit. In reality, a manufacturer's actual compliance opportunities will include the potential for engine technology improvements beyond those that exist today, the potential for off-cycle credits beyond stop-start credits, and the potential for some level of mild hybridization. Further, to the extent manufacturers do choose to apply strong hybridization or electrification, these technologies can provide a significant compliance benefit at even at low penetration levels.

[10] Note that the moderate load reduction case includes 10 percent mass reduction and 20 percent tire and aero improvements. In each of the low, moderate, and high load reduction cases, improvements are measured relative the mass, aero, and tire levels assigned to the corresponding vehicles in EPA's MY2015 baseline fleet. As one example, since EPA's PD assessment applies 12.5 percent mass reduction to the baseline F150, additional mass reduction is not applied in this technology walk for the low and moderate load reduction cases.

Table 2-2 Technology Walks with Existing Engines: Modeled Tailpipe CO_2 Values (g CO_2/mi)

	Corolla	Camry	RAV4 AWD	Highlander AWD	Tundra AWD	Fiesta	Fusion	Escape AWD	Explorer AWD	F150 AWD
2025 target (g CO2/mi, using 2015 footprint)	141	151	173	188	258	131	157	176	201	256
2025 Stop-start off-cycle credits (g CO2/mi)	2.5	2.5	4.4	4.4	4.4	2.5	2.5	4.4	4.4	4.4
2025 AC credits (g CO2/mi)	18.8	18.8	24.4	24.4	24.4	18.8	18.8	24.4	24.4	24.4
2015 actual vehicle, per test car list	205	232	268	335	456	216	228	271	362	362
MY2015 modeled	217	239	278	337	465	228	234	285	367	364
Delta: MY2015 modeled - actual veh	6%	3%	4%	1%	2%	6%	2%	5%	1%	1%

Technology Walk #1: Published Toyota engine, 2.5L Atkinson + CEGR, scaled to vehicle size and performance neutral

+ existing 8-speed and stop-start	187	201	233	288	400	183	194	231	313	331
+ trans and accessory improvements	173	184	217	265	369	170	179	216	291	308
+ low load reduction	164	170	199	246	340	154	169	197	267	300
+ mid load reduction	153	165	190	234	329	148	164	190	258	290
+ high load reduction	146	155	179	213	302	140	154	180	243	277

Technology Walk #2: Published Honda engine, 1.5L Turbo, scaled to vehicle size and performance neutral

+ existing 8-speed and stop-start	191	210	241	295	416	184	202	241	322	346
+ trans and accessory improvements	174	194	227	274	384	172	184	226	300	324
+ low load reduction	166	179	208	249	351	159	172	203	276	316
+ mid load reduction	155	174	199	239	339	152	167	195	266	301
+ high load reduction	147	159	184	226	315	145	157	183	248	282

Table 2-3 Technology Walks with Existing Engines: Gap to MY2025 GHG Target (g CO2/mi)

	Corolla	Camry	RAV4 AWD	Highlander AWD	Tundra AWD	Fiesta	Fusion	Escape AWD	Explorer AWD	F150 AWD
2015 actual vehicle, per test car list	-43	-60	-66	-118	-169	-64	-50	-66	-133	-77

Technology Walk #1: Published Toyota engine, 2.5L Atkinson + CEGR, scaled to vehicle size and performance neutral

+ existing 8-speed and stop-start	-25	-29	-31	-71	-112	-31	-16	-26	-83	-46
+ trans and accessory improvements	-11	-12	-15	-48	-82	-18	-2	-12	-62	-23
+ low load reduction	-2	2	3	-29	-53	-2	8	8	-37	-15
+ mid load reduction	9	7	12	-17	-42	4	14	15	-29	-4
+ high load reduction	16	17	23	3	-14	12	24	24	-14	8

Technology Walk #2: Published Honda engine, 1.5L Turbo, scaled to vehicle size and performance neutral

+ existing 8-speed and stop-start	-29	-38	-39	-78	-129	-33	-24	-36	-92	-61
+ trans and accessory improvements	-13	-22	-25	-57	-96	-20	-6	-21	-71	-39
+ low load reduction	-4	-7	-6	-32	-64	-7	5	1	-46	-31
+ mid load reduction	7	-2	3	-22	-51	-1	11	10	-37	-16
+ high load reduction	15	13	18	-9	-27	7	21	22	-19	3

Note: Assumes the application of available AC credits and stop-start off-cycle credits shown in Table 2-2. Values in green indicate numerical CO_2 values lower than (or approaching) the footprint target GHG values.

2.2 Effectiveness Modeling and Quality Assurance

2.2.1 ALPHA Model

Summary of Comments on the Draft TAR addressed in the Proposed Determination

Most comments on the Draft TAR that related to the ALPHA model were directed toward specific ALPHA inputs that EPA used for the analysis, rather than the model itself. Of the comments relating to the model itself, EPA received positive comments from the Union of Concerned Scientists, Environmental Defense Fund, NRDC, and others, pointing out the importance of using a physics-based, full vehicle simulation model such as ALPHA, and commending EPA's decision to make ALPHA and all of its inputs fully transparent and freely available to the public. Other comments on the ALPHA model included suggestions that EPA use the Autonomie model in place of the ALPHA model, on the grounds that industry is more familiar with Autonomie. EPA responded (TSD p. 2-268) that commercially available tools such as Autonomie cannot be made fully transparent and therefore are not the most suitable models to use for regulatory purposes, where transparency and replicability are critical and highly desirable elements. An additional comment was received regarding quality control and quality assurance parameters that can be used to verify the validity of model results in all output files. This topic is addressed in Chapter 5.3.3.2.3 of the Draft TAR and in the public release of the ALPHA model.[11]

Comments from vehicle manufacturers regarding the effectiveness values modeled in ALPHA for various individual technologies were addressed in the respective subsections of TSD Chapter 2.3.4. Additional comments regarding issues with EPA's engine sizing and performance were addressed in TSD Chapter 2.3.1.2, in which EPA further explains our methodology and how this relates to OEM product realities. Comments from industry regarding top gear gradeability were addressed in TSD Chapter 2.3.4.2, with the additional discussion that manufacturers are not currently maintaining top gear gradeability due to the inherent advantages of advanced transmissions. Accessory load assumptions were also raised in the comments. TSD Chapter 2.3.3.3.6 provided a further discussion of EPA's use of multiple values of accessory load values based on the vintage of the vehicle being modeled and how these values were derived from actual vehicle testing.

Summary and Response to Comments on the Proposed Determination

In comments on the Proposed Determination, NRDC highlighted a key finding of the 2015 NAS Committee, stating that the Committee found that the agencies' original analysis was "thorough and high caliber on the whole." NRDC also cited the position of a member of that Committee, that the Draft TAR and Proposed Determination analysis is "extremely thorough and of high caliber since its methodologies are consistent with the NAS recommendations to increase the use of these approaches" (referring to EPA's use of full simulation modeling combined with lumped parameter model, vehicle testing, and tear-down studies).

In reference to the peer review of the ALPHA model, the Alliance noted that the findings of the peer review were not available until October 2016 (when the peer review was completed and the report was published), and stated that the comment period on the Draft TAR therefore did not

[11] The public release of the ALPHA model is available at: https://www.epa.gov/regulations-emissions-vehicles-and-engines/advanced-light-duty-powertrain-and-hybrid-analysis-alpha.

provide stakeholders an opportunity to participate in the review or examine the model. In response, as indicated in the Draft TAR, all of the materials provided to the ALPHA model peer reviewers had been publicly posted on the EPA website, including the fully functioning ALPHA models (see Draft TAR p. 5-256); therefore, interested stakeholders in fact did have an opportunity to examine the ALPHA model since May 2016 when this information was posted. Additional fully functioning ALPHA models were publicly posted at the Draft TAR release, including the engine maps, transmission maps, and complete vehicle information used in the Draft TAR analysis. Further, in response to the Alliance's comment that they were not provided an opportunity to participate in the peer review, in conducting independent peer reviews EPA follows Science and Technology Policy Council guidelines, which specify that, "The Agency should not be involved, however, in the selection of individual peer reviewers and should avoid commenting on the contractor's selection of peer reviewers other than to determine whether the reviewers, once selected, meet the qualifications established."

In reference to the Alliance suggestion in their comments on the Draft TAR that EPA add a specific set of proposed quality control checking parameters, the Alliance suggested that EPA's response in the Proposed Determination was unclear as to whether ALPHA calculates these parameters, and criticized EPA's suggestion that stakeholders could modify ALPHA to add such parameters as desired. In response, we note that ALPHA includes extensive energy auditing measures which serve as a quality control checking mechanism. The energy auditing topic is addressed in Chapter 5.3.3.2.3 of the Draft TAR, Chapter 2.3.3.3.3 in the TSD, and in the public release of the ALPHA model.[12]

2.2.2 Lumped Parameter Model (LPM)

Summary of Comments on the Draft TAR addressed in the Proposed Determination

Comments on the Draft TAR regarding the Lumped Parameter Model (LPM) mostly focused on the applicability of the model and the accuracy of the efficiency results it projects.

The most detailed comments received were regarding the LPM modeling methods, powertrain efficiency, and quality control (QC) checking. Some comments from vehicle manufacturers s asserted that EPA's modeling methods overestimate the effectiveness of technologies at the vehicle level, and thus underestimate the required penetration rates of advanced technology required to meet the 2022-2025 standards. Specifically, these comments cite a study by Novation Analytics, contracted by the Alliance and Global Automakers, and a similar study done at Oak Ridge National Laboratory. EPA's response, found in Appendix A of the TSD, provided a detailed analysis of the shortcomings in the Novation analysis (submitted as an Attachment by The Alliance in their comments on the Draft TAR), and a clarification on the apparent misinterpretation by commenters of the conclusions of the Oak Ridge study. Among the deficiencies there noted, the Novation study assumes *a priori* that the MY2014 powertrain efficiency will define maximum achievable efficiency. Among other things, this assumption ignores possibilities of combinations of existing technology packages and subsystems, as well as likely technological improvements. The analysis, for example, failed to account for such technological developments that have already occurred, such as 24 bar turbocharged downsized (TDS) engines, cooled exhaust gas recirculation (cEGR), or the high expansion ratio Atkinson

[12] The public release of the ALPHA model is available at https://www.epa.gov/regulations-emissions-vehicles-and-engines/advanced-light-duty-powertrain-and-hybrid-analysis-alpha.

cycle engine with cEGR. These comments further stated that the LPM should incorporate "key vehicle and powertrain parameters which determine powertrain efficiency," by which the commenters mean accounting for the engine displacement and power in relation to the energy expended over the test cycles. These comments were addressed in TSD Chapters 2.3.3.2 and 2.3.3.5.4, which explained how the Proposed Determination included consideration of the powertrain efficiency metric as a quality control (QC) tool. Further comments about adopting QC checks to determine the plausibility of results are addressed in TSD Appendix B, which explained how EPA adopted an additional layer of QC check based on powertrain efficiency, as suggested in the comments.

EPA also received comments questioning how the LPM accounts for the baseline efficiency of vehicles. These comments are addressed in TSD Chapter 2.3.3.5.1, which further explains how the baseline vehicle technologies are fully accounted for in the analysis. It should be noted that this comment relates to identifying a proper regulatory baseline, rather than to the Lumped Parameter Model itself. The LPM identifies incremental improvements to that baseline. Comments received on the Draft TAR and Proposed Determination regarding the baseline fleet are reviewed in Chapters 2.7, 2.7.1, and 2.7.2 of this RTC document.

Summary and Response to Comments on the Proposed Determination

As previously stated with respect to the ALPHA model, the NRDC comments listed the LPM as one of the modeling approaches that the NAS Committee recommended for continued use in combination with full vehicle simulation.

The American Council for an Energy-Efficient Economy (ACEEE) commented, "For the PD, EPA undertook substantial additional analysis to further investigate those topics. In order to capture variations in power train technology effectiveness, EPA i) altered its vehicle classification to reflect variations in power-to-weight ratio and road load power and ii) used a power-to-weight correction factor within each class to adjust the effectiveness values produced by the lumped parameter model before those values were input to OMEGA. To address the QC point, EPA backed out power train efficiency for a representative set of vehicles in the compliance package and found that the resulting efficiencies were in fact reasonable. The agency's results support the conclusion that the 2025 compliance scenario presented in the PD is plausible."

The Alliance asserted that EPA failed to adequately document the steps taken to calibrate the LPM, did not provide the executable version, and did not provide clear directions for use of the spreadsheet version of the LPM. FCA reiterated its position that the LPM should be verified in some way with real-world data, and suggested that the lack of this verification makes it more critical that EPA should fully document the steps that were taken to calibrate the LPM.

The method for calibrating the LPM is basically unchanged from the 2012 FRM, although the inputs used to calibrate the LPM have been continuously refined based on the latest available data. For the 2012 FRM, the LPM was calibrated using data from multiple rounds of full vehicle simulation from Ricardo, under contract to EPA, along with real world data and other sources such as the National Academy of Science reports. For the Draft TAR, the ALPHA full vehicle simulation model was introduced to provide an additional level of detail and transparency to EPA's analyses. Transparency and underlying technical details were also increased through the addition of engine, transmission, and vehicle benchmarking still relying on the LPM to differentiate vehicle types. For the Proposed Determination analysis, the ALPHA model provides the calibration data across all vehicle types, and moves the LPM into a simpler role of providing effectiveness values between ALPHA and OMEGA. In addition, in response to comments from the Alliance on the Draft TAR, the Proposed Determination analysis further differentiates individual vehicles using the particular characteristics of each baseline vehicle to expand upon the resolution provided by the ALPHA calibration data. The calibration of the LPM is described in Chapter 2.3.3.5.2 of the TSD. The description of the ALPHA full vehicle simulation model along with the real-world data used to calibrate ALPHA is described in Chapters 2.3.3 and 2.3.4 of the TSD. Over 100 ready-to-run ALPHA models used to tune the LPM are available at the EPA ALPHA website.[13] Contrary to the Alliance's comments, EPA believes that the information provided in the TSD adequately describes the function of the LPM as well as how the LPM output represents incremental effectiveness.

The executable version of the LPM has never been used in the OMEGA analysis and was originally provided with the FRM as an aid for stakeholders to build OMEGA packages resulting in effectiveness values derived from the Ricardo simulations. As the LPM has expanded in scope since the Draft TAR, this tool would require the user to have specific knowledge to provide specific inputs that is well beyond the original simple intent of the tool and therefore is no longer supported. The appropriate reference files to examine OMEGA technology packages and LPM output are contained in the master set and machine files located in the OMEGA pre-processors.[14] These files were available at the time of the Draft TAR and Proposed Determination releases, and contain several hundred thousand technology combinations across all vehicle types, providing all possible technology packages considered in the OMEGA process without any user input required.

FCA revisited comments received by EPA on the Draft TAR, originally made by Global, regarding the ability of the LPM to predict the CO_2 emissions of vehicles from the MY2014 fleet. EPA had responded in part that the LPM should not be expected to predict absolute CO_2 emissions because it is not designed for that purpose.

As discussed in TSD Chapter 2.3.3.5, the LPM does not predict the absolute CO_2 emissions for specific vehicles in the baseline fleet. During preprocessing for the Proposed Determination OMEGA analysis, the LPM used results from the ALPHA full vehicle simulation model to estimate a specific net effectiveness value for each of the specific technology packages that OMEGA will be using for its analysis. For each baseline vehicle in its analysis, the OMEGA model starts with the vehicle's actual certified CO_2 value and applies the net effectiveness value for the specific technology package applied to that vehicle to arrive at an estimate of the improved vehicle's CO_2. This process has not changed since the 2012 FRM.

Docket memo EPA-HQ-OAR-2015-0827-5918 describes additional documents that were publicly available in support of the Proposed Determination detailing inputs used in the ALPHA full vehicle simulation model. These models and their inputs (engine maps, transmission maps, road loads, etc.) are completely transparent for examination and further analysis by stakeholders.

[13] The public release of the ALPHA model is available at https://www.epa.gov/regulations-emissions-vehicles-and-engines/advanced-light-duty-powertrain-and-hybrid-analysis-alpha.

[14] The cited materials can be found at: https://www.epa.gov/regulations-emissions-vehicles-and-engines/optimization-model-reducing-emissions-greenhouse-gases.

Global Automakers commented on what it describes as an error in the LPM that causes EPA's projected CO_2 savings for vehicles of different sizes to be the same when the same technology combinations are applied, which Global characterized as evidence of an error, on the grounds that large vehicles would be expected to show a greater CO_2 reduction than smaller vehicles. Global cited the specific example of the combination of Atkinson 1 with cylinder deactivation, going on to say that the raw data provided as part of the Proposed Determination suggested that this 'error' went uncorrected from the Draft TAR.

In response to the comment by Global Automakers, the Atkinson 1 engine technology is reserved for strong hybrid applications, and cylinder deactivation is not considered as an option. The Atkinson 2 engine technology used in advanced powertrain technology packages considers cylinder deactivation. The master set file cited in the comments submitted (MS_Control_in2025AB_20161118_icm_aeoR) does not contain the technology combination of Atkinson 1 and cylinder deactivation, and therefore would not be considered in the OMEGA analysis. EPA agrees that vehicles with a higher power-to-weight ratio will typically result in more effectiveness for a given package of technologies. Consider the following technology package in the same file (MS_Control_in2025AB_20161118_icm_aeoR), similar to many vehicles in the 2015 baseline:

LUB+EFR1+LRRT1+IACC1+EPS+Aero1+LDB+DCP+WR5%+TRX11

When this technology package is applied to a lower power-to-weight ratio vehicle (Type 1), the effectiveness improvement is 20.7 percent. This same technology package applied to a higher power-to-weight ratio vehicle (Type 15) has an effectiveness improvement of 23.7 percent. These effectiveness improvements apply to the exemplar vehicles for these vehicle types and are further adjusted based on the characteristics of the individual baseline vehicles, as described in TSD Chapter 2.3.3.2.

2.2.3 Quality Assurance / Plausibility Checks, ALPHA-LPM Calibration

Summary of Comments on the Draft TAR addressed in the Proposed Determination

Some comments received on the Draft TAR were critical of the processes used by EPA to assure the reliability and accuracy of the modeling tools. In a contracted study referenced in The Alliance comments, Novation Analytics stated that "[N]o 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" (pg. 44, Alliance comments). In the Proposed Determination, EPA responded that it did not agree that the processes used in the previous FRM and Draft TAR assessments did not involve plausibility checks. The LPM had been calibrated to, and was bounded by, the physics-based full vehicle simulation model results. It was not used to predict anything beyond the bounds of these fundamental inputs. As described in Appendix A of the TSD of the Proposed Determination, EPA considered each of the three metrics proposed by the Alliance and did not find any of them to be appropriate for use as plausibility checks of technology effectiveness. At the same time, we acknowledged that quality assurance processes are important for ensuring the validity of any modeling, and EPA adopted the use of the powertrain efficiency metric as a quality assurance tool for the Proposed Determination as described in TSD Chapter 2.3.3.5.4 and Appendix B of the TSD.

Summary and Response to Comments on the Proposed Determination

EPA received multiple comments on the discussion in Appendix A of the TSD which addressed the technology effectiveness studies undertaken by the Alliance's contractor, Novation Analytics. The comments submitted by the Union of Concerned Scientists (UCS), the International Council on Clean Transportation (ICCT), and the American Council for an Energy-Efficient Economy (ACEEE) generally concur with EPA's analysis that was presented in Appendix A of the TSD, and with the conclusion that the additional plausibility limits recommended by Novation were not justifiable. The comments received from the Alliance of Automobile Manufacturers (Alliance), the Association of Global Automakers (Global), Toyota, and Novation Analytics were more critical of EPA's consideration of the Novation work in the Proposed Determination. These commenters expressed the view that EPA did not provide sufficient explanation in the Proposed Determination for dismissing the plausibility limits recommended by Novation. Both Global and Novation commented that the methodologies used in the EPA and Novation work were fundamentally the same, and that EPA had improperly characterized Novation's methodology. These comments, while extensive, primarily offer criticisms of EPA's analysis and conclusions in the TSD Appendix A regarding the Novation studies and do not provide new information. They do not persuade EPA to alter our previous conclusion to not accept the recommended plausibility limits. We address the particular concerns raised in their comments below.

Differing Use of Key Concepts and Terminologies: The comments from Novation Analytics and the methodologies in their earlier studies use certain critical concepts differently from EPA, as well as in an inconsistent manner, making it difficult at times to assess or respond to them in detail. Specifically, the comments borrow some of EPA's terminology but appear to define or refer to certain key concepts differently compared to how EPA defined or referred to them in the TSD.

Consistent use of conceptual terminology is vitally important in discussing and describing the modeling analysis and results that are fundamental in the MTE. Novation expresses disagreement with EPA's assessment in the TSD of the critical flaws in their studies. Novation comments that their technical approach to characterizing technology package effectiveness is fundamentally the same as EPA's, and "by criticizing Novation, EPA is calling into question its own approach."

EPA disagrees that its modeling approach is the same as Novation's, and believes instead that the differing conclusions of the Novation study are largely premised on a misuse of key concepts and terms as applied in engineering models of vehicle operation. In particular, the concepts in the Novation materials represented by the terms "maps" and "full-vehicle simulation" are significantly different from the same language and terms used in EPA's technical assessments, leading to divergent results.

Novation uses the term "map" to mean a representation of the efficiency of a powertrain type (defined as the ratio of vehicle tractive energy to the fuel energy used) over a test cycle as a function of displacement specific operating load (a measure of powertrain sizing). EPA uses a variety of maps in its modeling process, but most commonly EPA uses the term "map" to refer to a representation of the efficiency of an engine (defined as the ratio of engine work out to fuel energy in) as a function of operating speed and load applied, with subsequent accounting in the full-vehicle simulation for the interaction with other components (including, critically, the transmission). Novation has explicitly stated in public descriptions of the ENERGY software used in its contracted work for the Alliance that the model does not include engine fuel maps, transmission shift strategies, or alternator maps that would be necessary to model technology combinations that are not currently available for physical testing. As the term is used by Novation, powertrain efficiency "maps" are unable to model component level improvements and alternative component combinations beyond those that exist today, unless some adjustments are made to incorporate input from component maps of the type used in EPA's full vehicle simulation to account for future engine, transmission, and other component technology. Novation has provided no indication that the Alliance-contracted work employs these component-level "maps" as defined and used by EPA in its TSD.

Novation uses the term "full-vehicle simulation" to mean the combination of a time-step road load simulation with a powertrain efficiency map to estimate the fuel energy consumed over a test cycle. Novation states that its road load analysis "does not impose arbitrary constraints, and thus the simulation enables the adoption of future levels of road load improvements that may not exist in the fleet currently." However, as explained above, the constraints imposed by Novation's limited use of powertrain efficiency "maps" preclude the consideration of technology improvements beyond the components and combinations that exist currently, and as a result, the results of Novation's full-vehicle simulation are predisposed to be artificially over-constrained. EPA uses the term "full-vehicle simulation" to mean a time-step simulation of engine, transmission, and accessory component maps, together with component interaction models and a road load model to estimate the fuel energy consumed over a test cycle. By modeling individual components and their interactions, EPA has applied the ALPHA full-vehicle simulation to model both vehicle-level performance of technology packages that exist today, as well as those that are expected to be available in the future.

In summary, EPA believes it is inappropriate to replace its analysis of the future fleet of vehicles with an analysis limited by the constrained modeling concepts implemented by Novation, as described above, because such an approach inherently would produce results that ignore both appropriate recombinations of current technologies and any future development, and show powertrain efficiency values which are constrained by the efficiency of current production powertrains. Even with the subsequent application of road load reductions by Novation (constrained to the levels projected by EPA in the FRM), the analysis conducted for the Alliance was predisposed to show a shortfall in the ability of conventional technology to meet the MY2025 standards. However, the inconsistent meaning and use of terms and concepts in Novation's comments make it difficult to compare their analysis to the methodology used in EPA's work.

General Material: In comments on the TSD, Novation Analytics stated that EPA's discussion in Appendix A of the TSD was "largely based on blogs[15,16] rather than fact-checked and peer-reviewed sources." This comment seems to imply that EPA did not perform its own technical assessment of the Novation Analytics work. This assertion is incorrect. The discussion of the Novation Analytics work detailed in Appendix A of the TSD consists of EPA's own

[15] David Cooke, "Five Deceptive Tactics Automakers Are Using to Fight Fuel Economy Standards," July 13, 2016, Union of Concerned Scientists, http://blog.ucsusa.org/davecooke/automakers-fuel-economy-standards.

[16] Alam Baum and Dan Luria, "Why We Believe the Auto Alliance Review of Fuel Economy Standards Misses the Mark," July 6, 2016, Ceres, https://www.ceres.org/press/blogposts/auto-alliance-review-misses-the-mark/.

analysis of Novation's reports, which were submitted by the Alliance in support of their comments on the Draft TAR, and previous briefings by the Alliance and Novation Analytics to the EPA. EPA expressed the view that its position was further supported by the fact that other parties such as UCS and Ceres independently came to similar conclusions about the Novation reports (as expressed via their official blogs). EPA notes that comments submitted on the Proposed Determination by UCS, ICCT, and ACEEE generally concur with the analysis that was presented in Appendix A of the TSD.

The Association of Global Automakers commented that "[b]y using the same inputs and basic methodology as EPA, Novation should have come to the same conclusions concerning the technological feasibility of the MY2022-2025 standards [as EPA did]." In response, EPA agrees that if Novation had actually used the same inputs and the same basic methodology, this would be the expected result. However, Novation did not do so. Instead, they "performed the study using a 'top-down' analysis, which evaluates scenarios using the overall energy conversion efficiency of the powertrain system" in contrast to "starting with a baseline performance value and adding percentage changes expected for a given technology as would be done in a 'bottom-up' study" as the EPA performed."[17] Thus, not only was the modeling methodology used by Novation different from EPA's, but also the required inputs used by Novation were different. It is clear that the Novation reports did not use "the same inputs and basic methodology as EPA" as Global contends.

ICCT also commented on the Novation studies, stating, "[o]verall, it should be noted that a 'top-down' analysis such as that offered by Novation should cast doubt on a detailed, simulation-based analysis such as that conducted by EPA only to the extent that the top-down analysis demonstrates that the simulation-based approach violates fundamental principles. The Novation report does not make any such demonstration, but rather imposes artificial constraints on how far and how fast technology can advance." EPA agrees with ICCT's assessment.

Both UCS and ACEEE commented on the Alliance's use of Novation's study to support their contention that "conventional powertrains will likely not displace the need for more electrification."[18] UCS and ACEEE disagreed with the Alliance's conclusion, with UCS commenting that "[i]n fact, the [Novation] report identifies two different scenarios where manufacturers would be able to comply with the 2025 regulations using conventionally powered vehicles," and that "these scenarios are generally consistent with EPA's technology pathways by deploying 24-bar turbocharged engines, stop-start, and high-ratio transmissions." ACEEE further comments that "given Novation's failure to properly account for technology advances, [this result] supports the conclusion that more stringent standards than those in place for MY 2022-2025 could be achieved."

In an introduction to their comments on the Proposed Determination, Novation advances two reasons for disagreeing with what it characterizes as EPA's main argument:

> "EPA's main argument is that Novation simply assumed MY2014 technology and levels of powertrain efficiency, making no consideration for powertrain and vehicle load technology advancements. On the contrary, the Novation studies assumed: (1) The same powertrain

[17] *Fleet-Level Assessment*, p.7.

[18] Alliance of Automobile Manufacturers Comments on Draft Technical Assessment Report, EPA-HQ-OAR-2015-0827-5711, p. iii.

technology pathways published in the FRM, which included aggressive turbocharging with engine displacement downsizing, high efficiency and high ratio spread transmissions, stop-start, and multiple levels of electrification. (2) The same vehicle load reductions published in the FRM, which included aerodynamic drag and tire rolling resistance reductions of up to 20% in addition to mass reductions of up to 10%."

In response, Novation's comment both misstates EPA's responses in the TSD and confounds different aspects of their own work. On the first point, Novation considered a number of powertrain "technology bundles," some of which do not exist in the MY2014 fleet (for example, 27 bar turbocharged engines with high ratio spread transmissions and stop-start). However, Novation confounds their inclusion of these technology bundles with their failure to properly assess potential technological advancement *within* each technology bundle. Within each bundle, Novation simply assumed, without providing substantiation, that the average powertrain efficiency in the future will be tied to the efficiency distribution within the MY2014 fleet, and improvements within a technology bundle are due strictly to "learning." In fact, there are multiple individual sub-technologies that can be applied to a powertrain which do not change its "bundle" as defined by Novation, but do increase the powertrain efficiency – for example, Atkinson or Miller cycle engines. The Novation process ascribes powertrain efficiency improvements due to the incorporation of additional technologies not as quantifiable advances, but as progression along a statistical "learning" curve.

However, all *combinations* of sub-technologies do not exist in the MY2014 fleet, and thus potential powertrain efficiency improvements exceed what is currently in the fleet. The statistical representation used by Novation for each technology bundle, which is tied to the efficiency of existing combinations in the MY2014 fleet, thus systematically underestimates potential future improvements due to new technology or recombinations of technologies already included in the powertrains within the bundle. This artificial limitation on technology improvement within each bundle was what was noted by EPA in the TSD as a fundamental inadequacy of the Novation study, not the existence (or lack thereof) of downsized turbocharged engines in Novation's studies.

On the second point, Novation again misstates EPA's discussion in the TSD. EPA pointed out that Novation did not consider *changes in the penetration rate* of vehicle load reductions published in the FRM, specifically in the portion of their analysis where it would be appropriate to do so. Moreover, Novation confounds the separate sections of their own analysis: EPA acknowledges that when Novation attempted to evaluate EPA's projected powertrain efficiency numbers, they appropriately maintained EPA's projected vehicle load reductions. However, this was not the point made by EPA in the TSD. EPA noted in the TSD that Novation did not consider *changing* the projected vehicle load reductions (or other non-powertrain aspects) in the latter part of their analysis where it *would* be appropriate to do so. Specifically, rather than consider possibly cost-effective decreases in road loads when evaluating "alternative technology deployment pathways that could allow the fleet to comply with the agencies' future model year standards,"[19] Novation unnecessarily maintained EPA's projected vehicle load reductions and considered only more advanced powertrain technology such as costlier HEV or BEV packages. By not considering additional vehicle load reductions as part of the alternative pathway, the

[19] Novation Analytics, *Technology Effectiveness – Phase I: Fleet-Level Assessment*, version 1.1, prepared for the Alliance of Automobile Manufacturers & Association of Global Automakers, October 19, 2015, p.64.

analysis is predisposed to require more expensive powertrain technology and therefore project higher costs and higher levels of technology usage.

Both of these comments are considered in further detail below.

Constraints on Technology Combinations: In Appendix A of the TSD, EPA stated that the methodology in the Novation report essentially assumes "that all possible technology available in 2025 can be represented by technology already contained in the MY2014 baseline fleet." In their comments, Novation disagreed with EPA's characterization, stating that they "used the current powertrains as a foundation upon which it added the technologies assumed by the FRM." Furthermore, they stated, "[t]his is fundamentally the same process that the agencies use: measure the performance of current production powertrains and powertrain components to establish a baseline, then add those technologies and technology combinations that do not exist in the fleet today. The difference is simply system-level analysis versus component-level analysis."

However, this is an example of where Novation inappropriately uses similar terminology to refer to different concepts in an attempt to draw a parallel between their process and EPA's. In fact, the specifics of the Novation process bear little resemblance to processes used by EPA, and their reference to a "system-level analysis versus component-level analysis" merely attempts to mask the fact that Novation's process systematically fails to account for the existence (and effect) of sub-technologies within their technology bundles, and thereby tends to under-predict potential improvements in technology effectiveness.

When EPA adds technologies to the baseline fleet, EPA uses multiple data sources, as described in Chapter 2 of the TSD, to determine effectiveness values for specific technologies alone and in combination, including some combined powertrain packages that do not exist in the fleet today (although most or all of the individual sub-technologies do exist). These individual technologies include, for example, variable valve lift and timing, Atkinson cycle engines, engine friction reduction, early torque converter lockup, gearbox efficiency improvements, and others.

In contrast, when Novation adds technologies to the baseline, they consider only broad categories of powertrain technology "bundles" (see Novation Comments at pp. 6 and 7), and set the efficiency range of these bundles such that the 50^{th} percentile of powertrain efficiency represents current fleet efficiency levels.[20] The potential existence of sub-technologies such as Atkinson cycle engines, engine friction reduction, early torque converter lockup, or gearbox efficiency improvements is not represented. This failure to consider the individual effects of known technologies is a critical and inherent shortcoming of the report.

In their comments, Novation points out, as evidence that their report accounted for technology advancement, that they included in their analysis "powertrain combinations [which] are not in production," specifically "advanced spark-ignition (SI) based powertrains [i.e., 24 bar turbocharged / downsized engines with cooled EGR] with high ratio spread transmissions and stop start." While true, this comment confounds the mere existence of powertrain bundles not in the fleet with the ability to account for additional technology added within a powertrain bundle – or more precisely, with the *a priori* methodological choice not to consider such technology additions. This necessarily leads to an underestimation of efficiency, as noted above.

[20] *Fleet-Level Assessment,* p.48.

In fact, Novation's process ensures that the powertrain efficiency of "future" powertrain bundles are tied to the specific sub-technologies that are included in those bundles in the MY2014 fleet. For example, under the Novation methodology, a naturally aspirated engine, high ratio spread transmission bundle would never be modeled with the combination of Atkinson cycle, engine friction reduction, cooled EGR, early torque converter lockup, and gearbox efficiency improvements, simply because that combination does not exist in the MY2014 fleet. However, there is no inherent reason why manufacturers cannot build such a package if they choose, and so the restriction in Novation's modeling artificially leads to lower estimates of potential powertrain efficiency improvement.

In like fashion, both the Association of Global Automakers and Toyota provided similar comments relating to EPA's criticism of Novation's methodology. Global stated that the criticism "misses the point of Novation's work, which was in part to assess EPA's contention that CO_2 targets can be met through advancements to the current internal combustion engines." Toyota claims that Novation's study includes "powertrain efficiency distributions and deployment scenarios [which] are mechanisms that account for technology advancement."

However, like the original reports authored by Novation, these comments confound an assumed advancement along a statistical curve due solely to "learning and implementation improvements"[21] with the incorporation of specific advanced technologies into a vehicle powertrain. EPA's analysis accounts for the effects on efficiency attributable to each sub-technology, and assumes that manufacturers will adopt the technologies of their choice as needed. In contrast, the Novation methodology simply assumes, *a priori*, that powertrain efficiency in 2025 is limited to small incremental improvements over that which is available today, regardless of available combinations of sub-technologies. In their comments, UCS, ICCT, and ACEEE agree with EPA's assessment of the Novation methodology, with ACEEE commenting that Novation "assumes a given technology can be no more efficient on average in 2025 than the best implementations of that technology in 2014. This is an arbitrary constraint that clearly does not apply for all technologies."

In Appendix A of the TSD, this inappropriate confounding of advancement along a statistical curve with the incorporation of specific advanced technologies was discussed, presenting the example of vehicles with Atkinson cycle engines or engines with cylinder deactivation, which would presumably be included primarily within a bundle of SI naturally aspirated engines, coupled with a non-high ratio spread transmissions and without stop-start.

In their comments, Novation responded that they were "requested to consider" only vehicle packages used in the FRM, and "not alternative powertrain technologies that EPA may now be evaluating (Novation comments p. 7)." EPA acknowledges that Novation may have been following the request of the contracting organizations, the Alliance and Global, in not explicitly considering the effect of Atkinson engines or cylinder deactivation technologies. However, such direction to Novation does not mean EPA should disregard the resulting limitation in Novation's work product. It is indisputable that Atkinson engines and cylinder deactivation exist in the MY 2014 fleet, yet the Novation methodology does not account for these actual technologies, instead lumping all powertrains into generic groups and mistakenly attributing the actual differences in powertrain efficiency due to advanced technology as "learning and implementation

[21] *Fleet-Level Assessment,* p. 78.

improvements." This lack of accounting for real technology, whether or not included in the FRM, underscores the flaw in Novation's methodology.

Furthermore, in their comments, Novation states "the LPM, on which most of Novation's analysis was focused, describes powertrains by broad technology packages ... In the Proposed Determination, EPA continues the practice of defining powertrains as broad technology packages; hence, by criticizing Novation, EPA is calling into question its own approach." This mischaracterizes the usage of the LPM and again highlights the flaws in Novation's approach to package building. EPA's technology packages are combinations of specific technologies, where the effect on CO_2 emissions of each sub-technology is accounted for in the aggregate package. In contrast, Novation's technology bundles include powertrains incorporating a range of different technologies, and all powertrains in the bundle are assumed to have an equivalent level of technology. For example, as noted in the TSD and above, the Novation analysis would class Atkinson cycle engines or engines with cylinder deactivation along with other naturally aspirated engines, with no differentiation.

Responding to criticism of a lack of technical rationale for using a CI (diesel) engine as a "proxy" to represent a 27 bar SI (gasoline) engine, Novation states (p. 8) that in their approach, "the key attributes that allow diesel engines to achieve higher efficiencies than current spark-ignition engines... are the same benefits that EPA was claiming for the direct-injected, dilute, and highly boosted engines that served as the foundation of the FRM." Although EPA agrees that the use of CI engine efficiency to represent a 27 bar SI engine is directionally correct, the context of these comments highlights the differences between the EPA analysis and the approach used by Novation in their studies. Rather than rely on superficial similarities between engine technologies to estimate engine efficiencies as Novation does, EPA evaluates the SI engines themselves. Consequently, there is no need to rely on a proxy engine of a different type and results in a more robust analysis.

Vehicle Load Penetration Rate Changes: In Appendix A of the TSD, EPA noted that the Novation study did not examine the effect of potential changes in vehicle load reduction penetration rates, even in circumstances where it is clearly appropriate to do so. In comments referring to this discussion, Novation states that their study "assumed the same mass, aerodynamic drag, and tire rolling resistance reductions as assumed by the agencies in the FRM." However, this comment confounds the consideration of changes in vehicle load reduction *penetration rates* with incorporation of vehicle load reduction as a technology at all.

Novation states that their objectives in the studies were "to evaluate the sustainability of the FRM powertrain effectiveness assumptions, not the vehicle load assumptions." A comment by the Association of Global Automakers made a similar point. However, the Novation report goes beyond simply evaluating powertrain effectiveness assumptions. Novation also uses their analysis to model "alternative technology pathway scenarios,"[22] where they seek to quantify the technology penetration mix required to meet the MY2021 and MY2025 standards in an alternative compliance scenario where powertrain technology effectiveness is lower.

Novation further states in their report that the entities commissioning the report, the Alliance and Global, specifically requested this analysis be done "given the levels of vehicle energy

[22] *Fleet-Level Assessment*, p. 64.

reductions forecasted by the agencies,"[23] which narrowed the focus of the study to powertrain efficiency requirements only, and disallowed consideration of changes due to additional vehicle load reductions. In response, EPA notes that potential changes in vehicle load reduction penetration rates can reduce the need for addition of other technologies – particularly HEV and BEVs – in the alternative technology pathway scenarios proposed by Novation. The decision to omit vehicle load penetration rates from consideration thus leads to projections of a greater need for relatively costly powertrain technology additions.

As further support for its decision to hold road load reductions constant, Novation suggests that EPA keep also kept its vehicle penetration rates constant across the fleet in its analysis, saying "in both the TAR and Proposed Determination documents, EPA uses the same, generic, assumptions for [reduction in mass, aerodynamic drag, and tire rolling resistance] as it did in the FRM. Again, by criticizing Novation, EPA is calling into question its own assumptions." However, it is not the case that EPA kept its vehicle penetration rates constant.

Novation's statement appears to confound discrete levels of reduction in vehicle load parameters and overall penetration rates of these technologies into the fleet. For example, when building future vehicle packages, EPA assumes, as a modeling convenience, discrete levels of reduction in mass, aerodynamic, and rolling resistance loading. These levels have remained the same since the FRM. However, EPA's OMEGA model assumes that manufacturers will choose the most cost-effective technologies throughout their fleet to comply on a fleet-wide basis. When technology cost or effectiveness numbers change based on stakeholder input, the penetration rates of specific technologies, including vehicle load reduction technologies, can also change. Thus, although EPA has kept the definition of vehicle load reduction levels constant, that does not mean EPA has kept vehicle load reduction *penetration rates* constant across the fleet, as Novation erroneously states. This is another example of a significant difference between the Novation Analytics analysis and the EPA analyses; EPA applies technology in packages with increasing content where individual technologies have been modeled with high fidelity. Changes in road load result in significantly different engine and transmission operation, which affects the overall effectiveness of the entire technology package. EPA believes that this process best reflects how manufacturers design and develop vehicles to optimize the efficiency of the vehicle as a system.

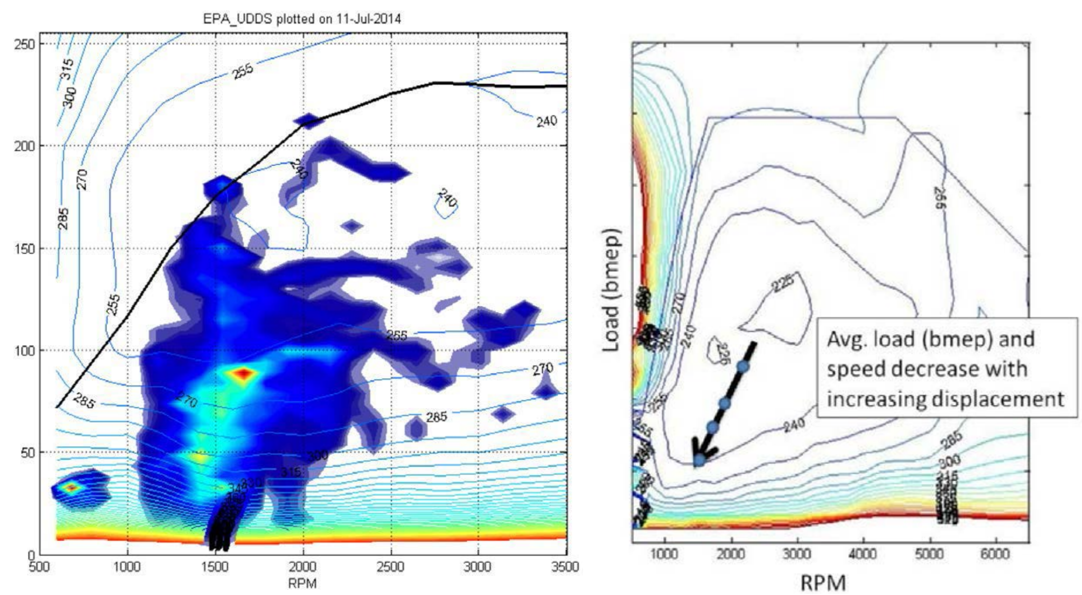
Plausibility Checks: In their comments, Novation states that "plausibility checks show individual vehicle simulations from the FRM that had *cycle average efficiencies* that were higher than the *peak engine efficiency* of the best engine maps used in the FRM, which is an impossible outcome." EPA agrees that average cycle efficiencies exceeding peak engine efficiencies is impossible, but more importantly EPA has examined the average cycle efficiencies of the packages used in the TSD and found no such cases. In fact, the vast majority of the technology packages applied in the PD central analysis for 2025 have average cycle efficiencies no more than 84 percent of the peak engine efficiency, and no applied technology packages have average cycle efficiencies more than 92 percent of the peak engine efficiency.

In the TSD Appendix A, EPA referenced an article by the Union of Concerned Scientists which claimed that one current production vehicle, a Honda Fit, would be deemed implausible by the Novation methodology. In their comments, Novation disagrees, stating "Novation would

[23] *Fleet-Level Assessment,* p. 64.

not deem the Honda Fit implausible. The MY2016 Fit is within the best 1 percent of SI-based powertrains, having a combined efficiency of 25.5 percent; yet, it is 12 percent below the stated plausibility limits established by Novation Analytics." EPA acknowledges that Novation's calculation of the Honda Fit powertrain efficiency is correct.

In the TSD Appendix A, EPA gave an example of the overly restrictive assumptions Novation uses, specifically using current engine technology to determine the limit of on-cycle-to-peak engine efficiency ratio ("Plausibility Test 2"). The example refers to two engine maps, a MY2013 Chevrolet Malibu 2.5L I4 GDI map and a 27-bar BMEP cooled EGR turbo GDI map (Figure 1.1 in the TSD Appendix A, and reproduced as Figure 2-6 in this RTC document). The 27-bar BMEP cooled EGR turbo GDI map has an enlarged area of high efficiency in the lower left (indicated by the arrow in Figure 2-6b). Since this is the area where engines tend to run over the cycle, the figure shows an example of how the application of engine technology can result in a better match between engine operation and peak efficiency. This reduces CO_2 emissions, precisely by increasing the on-cycle-to-peak engine efficiency ratio. A comment received from UCS agrees, stating in addition that "[l]owering this ratio is precisely the objective of much of the research on conventional spark-ignition engines."



(a) MY2013 Chevrolet Malibu 2.5L I4 GDI (b) 27-Bar BMEP Cooled EGR Turbo GDI

Figure 2-6 Two Engine BSFC Maps, Reproduced in Technology Effectiveness – Phase II: Vehicle-Level Assessment

NOTE: These maps are cited during the development of "Plausibility Test 2." The left-hand map is overlaid with areas of typical on-cycle engine operation. Original sources are given in the Novation report.

However, because the Novation report develops their plausibility limit for on-cycle-to-peak engine efficiency ratio based on a few MY2013-2014 vehicles, there is no room left below their arbitrary limit for the potential improvement in the efficiency matching shown in Figure 2-6. Put another way, the plausibility limit developed by Novation implicitly assumes that any potential improvements in engine technology which increase the efficiency of the engine while operating, relative to peak engine efficiency, are implausible.

Novation, in their comments, disagrees with the EPA assessment that they have no room for potential improvement due to efficiency matching, saying, "Novation assumed future improvements to on-cycle-to-peak engine efficiency ratios of 19 percent on the city cycle, 10 percent on the highway cycle, yielding 15 percent combined." However, the assumed future improvements cited by Novation are specifically tied to the implementation of two technologies: engine stop-start and higher ratio spread transmissions.[24] Neither of these technologies alters the area of peak efficiency on the engine map, and thus, there is no accounting for potential improvement in the efficiency matching as stated in the TSD. A comment received from UCS agrees with this assessment, pointing out that the limit that "the ratio of test cycle efficiency to peak efficiency should not exceed 0.78 is violated by engines already now in prototype."

Novation in their comments further disagrees with EPA's example of the overly restrictive nature of their plausibility checks by stating that EPA "relies on an illustrative example of an engine map that is not from an actual, tested engine." In response, EPA agrees that this is an illustrative example, all the more so since the 27 bar map shown, and included in Novation's original report, contains the overlaid arrow indicating how the area of greater efficiency is expended to the lower left, to better match the operating range of the engine during vehicle cycle operation. This is specifically illustrative of potential improvement in efficiency matching, and also illustrates UCS' comment that lowering the on-cycle-to-peak engine efficiency ratio is precisely the objective of much of the research on conventional spark-ignition engines.

Novation continues in their comments, "[f]urthermore, the technology assumed from this map was not included in the TAR or the Proposed Determination." Although this statement is something of a non sequitur, the 27 bar Ricardo map shown in Figure 2-6, and the underlying technology package, was indeed used to create 24 bar turbo downsized maps for the Draft TAR and the PD.

In their comments on the Proposed Determination, the Alliance reiterated their recommendation that EPA adopt the "plausibility checks" developed by the Alliance's contractor, Novation Analytics, and stated that EPA did not provide any reason for rejecting the methodology recommended. EPA has considered the proposed plausibility limits developed by Novation and explained the reasons for not adopting them, discussing these points at length in Appendix A of the TSD. EPA has also considered Novation's additional comments on the issue, and does not find them persuasive, as discussed above. EPA thus is not adopting the recommended plausibility checks.

In their comments, both the Alliance and Novation furthermore stated that EPA did not propose alternative numerical limits to the plausibility checks developed by Novation. These comments presuppose that the development of a numerical "plausibility" limit is necessary. EPA discussed at length in Appendix A of the TSD the shortcomings of the proposed plausibility limit calculation, and as an alternative noted that "calculation of powertrain efficiency can serve as a gross QC check on estimated technology effectiveness by quickly identifying the highest efficiency packages for further review (as shown in Appendix B [of the TSD])." Correctly and effectively using powertrain efficiency analysis as a QC check does not require the adoption of arbitrary limits, and EPA declines to do so.

[24] Novation Analytics, *Technology Effectiveness – Phase II: Vehicle-Level Assessment*, version 1.0, prepared for the Alliance of Automobile Manufacturers & Association of Global Automakers, September 20, 2016, p. 28.

Other Considerations: In Appendix A of the TSD, EPA disagreed with the assertion by the Alliance and Novation that the Lumped Parameter Model [LPM] is “not based on the fundamental factors determining vehicle CO_2 and fuel consumption.” EPA further explained the usage of the LPM, in particular the LPM "exemplar" vehicles, each of which has different engine sizes and road loads. The differences between exemplar vehicles does indeed account for the “fundamental factors determining vehicle CO_2” that Novation refers to, as the power-to-weight ratios of the exemplar vehicles vary, altering the relative areas of the engine map where each vehicle operates. In their comments on the TSD, Novation asserts that the LPM “provides the processing speed required to support the OMEGA model.” Although this is another non sequitur, EPA does not disagree with this assessment.

In their comments, Novation further states that “there was a lack of information published by EPA,” and that EPA “has been resistant to providing support for these studies.” They furthermore cite an email from Michael R. Olechiw (Director, Light-duty Vehicles and Small Engines Center, US EPA) to Greg Pannone (President, Novation Analytics). This email was regarding details of the 2010 FRM. The purpose of the ongoing inquiries from Novation Analytics is now clear, as Novation has explained the scope of their work as being limited to a study of the 2010 FRM. If EPA appeared dismissive in its response, it was because the MTE is intended to consider the MY2022-2025 standards, and it was therefore difficult to understand how the 2010 FRM (which established standards for MY2012-2016) results were relevant. EPA did offer to discuss the email with Novation; however, the offer was declined.

Additionally, in their comments, both the Alliance of Automobile Manufacturers and the Association of Global Automakers state that the methodology Novation used was shared with EPA in 2014 and “EPA never raised concerns or provided feedback indicating that they found the methodology insufficient or lacking in any way.” EPA in fact conducted numerous meetings with multiple stakeholders as part of the process of gathering information to inform the Midterm Evaluation process. Rather than respond to each stakeholder individually and in real time, the sum total of information gathered from stakeholders was synthesized into the Draft TAR. When the Alliance indicated that they disagreed with some points in the Draft TAR and, in support, formally submitted reports from Novation as part of the comment period, EPA replied to those comments in the Proposed Determination.

Novation additionally states that “[t]he methodology used by Novation... has been independently reported by other research.... Consequently, to suggest that this approach is without merit is to suggest that these other authors and peer reviewers were also incorrect.” Indeed, the use of tractive work and powertrain efficiency metrics is well-known, and can be a useful modeling technique when applied in an appropriate way. However, EPA does not agree that it was applied appropriately throughout the Novation study. Novation interprets EPA’s statements over-broadly, implying that EPA’s criticism is of the techniques themselves rather than the application thereof. EPA specifically rejects the implication that statements in Appendix A of the TSD apply to researchers who apply these techniques appropriately.

2.2.4 Vehicle Classifications

Summary of Comments on the Draft TAR addressed in the Proposed Determination

In the 2012 FRM and Draft TAR analyses, vehicles were classified into 19 vehicle types, which were based on six size-based categories for estimating effectiveness, and several cost categories defined by the various engine and valvetrain configurations most prevalent in the baseline fleet. While overall this method of grouping placed similar vehicles together, stakeholder comments on the Draft TAR highlighted some examples where dissimilar vehicles were assigned the same cost and effectiveness benefits.

In response to these comments, as described in TSD Chapter 2.3.1.4, EPA refined the vehicle classification approach for the Proposed Determination in several ways. First, we classified vehicles according to the attributes of vehicle road load power and engine power-to-vehicle weight ratio for the purpose of assigning the most representative estimates for technology effectiveness (see Chapter 2.3.3.2 of the TSD). Second, we implemented a classification by vehicle curb weights, together with engine configuration and the capability for heavy towing, as attributes used for assigning technology costs. Third, we expanded the number of vehicle types from 19 to 29.

Compared to the Draft TAR, the 29 vehicle types used for the Proposed Determination each contained a narrower range of values or the vehicle characteristics that have the greatest influence on technology effectiveness and cost: power-to-weight ratio, road load power, curb weight, and original engine configuration. Overall, consistent with the public comments, this updated classification approach provided greater resolution than the 19 vehicle types used in the Draft TAR, and advanced the goal of applying the most representative cost and effectiveness estimates for technologies applied to the MY2015 fleet.

Summary of Comments and Responses on the Proposed Determination

The Union of Concerned Scientists (UCS) expressed support for the changes in classifications to a power and road load basis, characterizing this change as responsive to “one of the strongest industry concerns” expressed in comments on the Draft TAR. UCS further stated that the updated classifications strengthen EPA’s analysis by “narrowing the error bars and more accurately representing the real vehicle fleet.” The American Council for an Energy-Efficient Economy (ACEEE) also positively highlighted this change when describing the additional analysis EPA performed for the Proposed Determination.

2.2.5 Performance Neutrality

Summary of Comments on the Draft TAR addressed in the Proposed Determination

EPA’s assessments for the 2012 FRM and Draft TAR were based on the application of technology packages while holding the underlying acceleration performance constant. To achieve this, ALPHA modeling runs were used to generate technology effectiveness values while maintaining a set of acceleration metrics within a reasonable window by adjusting engine displacement.

The Alliance of Automobile Manufacturers, in comments on the Draft TAR stated, "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." For the Proposed Determination, EPA continued to apply the constant performance criterion, and did not attempt to model discrete engine sizes or fleet-wide performance improvements that are made available, at least in part, by the efficiency technologies adopted to comply with the standards. As discussed in TSD Chapter 2.3.1.2, even if our model produces a greater variation in technology packages than exists today, this does not require that manufacturers actually produce a greater variety of component sizes than exist currently in order for our overall results to be valid. In actual vehicle design, manufacturers will design discretely sized components, and for each vehicle choose the available size closest to the optimal for the given load and performance requirements. For example, in some cases, the chosen engine will be slightly smaller than optimal (and thus have lower fuel consumption), and in some cases the chosen engine will be slightly larger than optimal (and thus have higher fuel consumption).

Other comments on the Draft TAR criticized the use of acceleration time as the main metric used to represent performance neutrality, and stated that top gear gradeability is another key metric that was omitted in the analysis. For the Proposed Determination, EPA did not incorporate gradeability as an additional performance metric. As discussed in TSD Chapter 2.3.4.2.2, maintaining top gear at 75 mph up a grade, as the commenters recommend, may not be appropriate for advanced eight-speed transmissions, where EPA testing has indicated downshifts regularly occur and are likely to be less noticeable to the driver (due in part to the smaller step changes in speed between each gear of a higher-gear-number transmission, as discussed in TSD Chapter 2.2.3.10 at p. 2-59).

<u>Summary and Response to Comments on the Proposed Determination</u>

In comments on the Proposed Determination, the Alliance of Automobile Manufacturers noted that within the ALPHA files generated for the Proposed Determination, the "Truck" class file shows 0-60 mph acceleration times averaging 15.9 seconds. A discussion of "performance ballast" was not included in the TSD, and EPA thanks the Alliance for pointing this out. To model the acceleration performance of the truck class, an additional performance weight was added to the ETW to simulate hauling a load. The value of the "performance ballast" (3000 kg) was noted in column J of the ALPHA files referred to by the Alliance in their comment.

The performance ballast was not used during the standard FTP and HWFET emissions cycles, but only during the performance cycle used to calculate acceleration times. The acceleration performance times noted by the Alliance reflect the presence of the added mass. The approach of ensuring performance neutrality while hauling 3000 kg generally results in more conservative technology effectiveness than would be obtained by using simply ETW or curb weight during the acceleration cycles.

The Alliance also suggested in comments that EPA incorporate a gradeability metric into the performance calculation, such that the vehicle "maintain[s] top gear at 75 mph while climbing a given grade." The subject of gradeability was discussed in the TSD Chapter 2.3.4.2.2, where EPA stated that "EPA does not believe this metric is appropriate for advanced eight-speed transmissions;" however, the Alliance disagreed with EPA's assessment. In response to the Alliance's comment, EPA has identified from publically available sources 14 examples from MY2012 to MY2017 where vehicles were refreshed, maintaining the same chassis and engines but incorporating transmissions with wider ratio spreads.[25] Twelve vehicles maintained curb weight within 1 percent; of the remaining two, one increased curb weight by 4 percent and one decreased curb weight by 4 percent; the average curb weights for the 12 vehicles remained unchanged. For each vehicle, the top gear ratio (including final drive and accounting, in a single instance, for tire size difference) was calculated. In all 14 vehicles, the top gear ratio was reduced, by 12 percent on average. Although top gear ratio and vehicle weight are not the only

[25] See docketed spreadsheet "Comparison of transmission top gear for selected vehicles.xlsx."

components in the calculation of top gear gradeability (other quantities such as change in wide-open throttle torque at speed and transmission efficiency play a small role), they are the largest factors, and directionally indicative of manufacturers' choices when implementing transmissions with wider ratio spreads. EPA stands by its analysis that top gear gradeability is not an appropriate metric when judging performance of advanced eight-speed transmissions.

Further, in considering the Alliance's comment, EPA used its ALPHA tool to estimate gradeability of the vehicle technology packages used to calibrate the lumped parameter model. For the Draft TAR, the calibration packages were constructed with a consistent final drive ratio, but for the Proposed Determination, a dynamic final drive resizing algorithm was adopted which increased the final drive ratio as engines were downsized. This algorithm resulted in top gear ratios that more closely match industry trends; the resulting gear ratios are included in the ALPHA calibration files available on the EPA website.[26] The results were that packages modeled with the TRX21 transmission, when properly matched for acceleration performance, outperformed the baseline vehicle in gradeability in most cases. In the two cases where it did not, gradeability was reduced by 0.5 percent of grade. Packages modeled with the TRX22 transmission and advanced engines also generally outperformed the baseline vehicle in gradeability. In many cases, this was due to higher available torque at engine rpm equivalent to 75 mph. For three of the six vehicle classes, all advanced packages showed improved gradeability. For two of the classes, gradeability results were mixed, with gradeability improving up to 3 percent of grade for most packages and decreasing less than 0.5 percent of grade for some packages. For the final HPW class, gradeability increased around 2 percent of grade for some packages and decreased less than 1 percent of grade for the remainder. Packages modeled with the base GDI engine and TRX22 transmission had in some cases further reduced gradeability. Thus, the gradeability generally improves when the acceleration performance is held constant, and EPA continues to believe that matching acceleration performance as a metric is the appropriate way to ensure performance neutrality.

2.3 Estimated Costs (Technology Costs, Total Costs, Learning)

This chapter reviews key comments on the general topic of costs. Comments relating to cost as it applies to the EPA analyses range across a wide variety of topics, including estimates of technology costs for specific technologies, projections of compliance costs for individual manufacturers and across the fleet, modeling of specific types of costs such as direct and indirect costs, the impact of manufacturer learning, and other related topics. Many of our responses to comments related to cost are therefore distributed among the other chapters of this RTC document that deal more specifically with various assessment and modeling topics and our assessment of specific technologies.

<u>Summary of Comments on the Draft TAR addressed in the Proposed Determination</u>

Numerous comments on the Draft TAR presented general arguments that EPA's estimated costs are too optimistic (primarily from industry commenters) or are too conservative (primarily from NGO commenters). In many cases, these comments can be described as general comments because they express an overall viewpoint on costs, though commenters included varying degrees of supporting evidence for their position, or evidence that was not readily applicable or

[26] ALPHA v2.1 Calibration Sample, available from https://www.epa.gov/regulations-emissions-vehicles-and-engines/advanced-light-duty-powertrain-and-hybrid-analysis-alpha.

not relevant to assessing the cost, effectiveness, and implementation feasibility in MYs 2022-2025. EPA responded to such comments in the context of the specific cost-related issues that commenters raised.

In commenting on the Draft TAR, multiple comments from NGOs (American Council for an Energy-Efficient Economy (ACEEE), Union of Concerned Scientists (UCS), and Environmental Defense Fund (EDF)) supported EPA's use of Indirect Cost Multipliers (ICMs) rather than retail price equivalents (RPEs) as a means of estimating indirect costs.

We also received some comments on our modeling of cost reductions through manufacturer learning. Ford argued that product cadence does not allow for cost reductions from learning to be realized since new products are constantly being developed. In the Proposed Determination, we noted that the learning effects we estimated should be taken as occurring at the level of the supplier, not that of the automaker. Since we have not estimated efficiency improvements to individual technologies during the time frame of the analysis, we do not believe that such redesign to improve the "current best technology" to the "next best technology" is necessary to achieve the reductions we expect for the costs we have estimated. More discussion of these comments and responses and the use of ICMs may be found in TSD Chapter 2.3.2 at p. 2-214 and TSD Chapter 2.3.2.2.1 beginning at p. 2-223.

Summary and Response to Comments on the Proposed Determination

Many of the comments on the Proposed Determination related to cost were largely similar to those received on the Draft TAR, in that they expressed general arguments that the costs were either too optimistic or too conservative, supported by varying degrees of supporting evidence or information. Many of these comments may be described as general comments and some express viewpoints that are shared by multiple commenters, so a response directed to one commenter may also apply to other commenters. Many of our responses to comments related to cost are distributed among the other chapters of this RTC document that deal more specifically with various assessment and modeling topics and our assessment of specific technologies.

Consumers Union stated its assessment that the standards are cost effective. Consumer Federation of America was also supportive of EPA’s technology cost estimates, presenting arguments supporting its position that industry tends to overestimate the cost of complying with regulatory standards.

The Alliance and some individual OEMs stated that differences in compliance cost estimates between the EPA and NHTSA analyses in the Draft TAR suggest that the agencies disagree about how OEMs can comply. EPA disagrees, and believes that this is a misinterpretation of the results. In the Draft TAR, EPA, NHTSA and CARB concluded that the standards can be met predominantly with advanced gasoline technologies and very low penetration of electric vehicles, although the modeling supporting those conclusions projected slightly different cost impacts. This is to be expected given the differences in modeling tools and inputs between the two agencies, as clearly explained in the Draft TAR (for example, in Draft TAR Chapter 2.3 which describes the agencies’ approach to independent GHG and CAFE analyses).

Subaru commented that our estimated costs are surprisingly low and argues that a limited-line OEM like Subaru has a much narrower path to compliance than EPA assumes. Subaru also argues that, even if ICEs achieve a brake thermal efficiency (BTE) of 50 percent, Subaru would need significant electrification to comply. However, because the EPA analysis has not specified that Subaru would have to achieve any specific level of BTE in its engines in order to comply, the significance of this specific example is unclear, and the comment provides no additional information to evaluate the claim or compare it to the assumptions in the EPA analysis to understand why the projections differ. Further, our analysis shows no increased electrification for Subaru beyond that necessary for the ZEV program (see Table C.21 of the Proposed Determination). In addition, EPA does not agree that the limited-line nature of Subaru's fleet impacts compliance pathways or that its customer demands make compliance more difficult than for other OEMs. Subaru's fleet consists largely of vehicles placed on the truck curve, which has considerably higher CO_2 targets for each footprint value than does the car curve. Subaru also questions the $0 cost of 60 percent of Subaru's earned GHG credits. However, this comment appears to be directed at the NHTSA analysis, since EPA did not make any such valuation of earned credits.

ICCT commented that EPA could reduce per vehicle costs by "several hundred dollars" by removing technology availability restrictions and including or expanding upon available technologies. However, we have chosen to remain consistent with the 2012 FRM's determination of technology availability restrictions (technology penetration caps), recognizing that this likely makes our analysis more conservative. See also the response in Chapter 2.5.3 of this RTC document where we address a similar ICCT comment with regard to engine technologies.

Ford reiterated that increased cadence of technology implementation limits opportunity for learning to reduce costs. Ford also argued that consumers do not value fuel economy highly enough to recover what they expect to be the additional costs of complying with the standards. We disagree with the latter position and discuss this more in Chapter 3 of this Response to Comments document. As for the impact of cadence on learning, as we discussed in the Proposed Determination, our learning impacts are assumed to occur at the supplier level rather than the OEM level (see the Proposed Determination TSD Section 2.3.2 at page 2-2015). As such, a possible transition from naturally aspirated to 18-bar turbocharging to 24-bar turbocharging for the OEM is not expected to impact the suppliers' learning on the turbochargers themselves. Ford also argues that EPA should assess the comprehensive cost increments related to both Tier 3 and GHG compliance. We believe we have done this by analyzing the Tier 3 requirements in that rulemaking and the GHG requirements via the 2012 FRM and again in the Draft TAR and the Proposed Determination.

Honda states that it believes "the targets for 2025 are correct, and consistent with long-term environmental goals," but also states that "compliance costs are more than double the amount estimated by the agencies," stating that the technology needed to comply is underestimated while marketing challenges are another difficulty. Honda's comment on the Proposed Determination did not contain detailed written remarks and primarily directed EPA to the comments by Global Automakers, and stated that Honda generally supports those comments.[27] EPA has responded to the comments from Global in the chapters of this RTC document that correspond to the specific detailed topics that Global raises, and EPA's response to Honda's comments are therefore represented by those responses.

[27] At the time of its comment, Honda also provided to the Docket a redacted copy of a presentation delivered to EPA on November 9, 2016.

Mercedes-Benz also commented that EPA overestimates its ability to comply and underestimates the cost of complying, is concerned that the cost of compliance will be higher for the Mercedes fleet than for competing OEMs with a more diverse fleet (due largely due to expectation of a greater than projected reliance on electrification), and requests that EPA consider additional flexibilities to promote a level playing field. Comments that relate to a higher need for electrification than EPA projects are addressed in Chapter 2.1 of this RTC document, while comments related to credits and flexibilities are addressed in Chapter 3.9.

Mercedes-Benz also commented that they anticipate their costs to be higher because designing, certifying, training, and stocking of parts for a low volume electrified product is not cost-effective. In response, EPA notes that Mercedes-Benz has a long history of including relatively low volume, somewhat "niche" vehicles with conventional powertrains (often high-performance) in their product line, and does not see a compelling rationale as to why it expects these issues to affect low volume electrified vehicles more strongly than they affect these low volume conventional vehicles. Mercedes also expressed concerns with design cost amortization for small volume manufacturers. However, Mercedes currently designs and sells a wide variety of products, and these products are regularly equipped with a variety of features and technologies that are leading edge. EPA believes that Mercedes, and other lower volume, high performance and luxury vehicle manufacturers, will manage their cost amortization the same way they do for all of the features that are not related to improving vehicle efficiency.

2.4 Lead Time

Summary of Comments on the Draft TAR addressed in the Proposed Determination

Lead time is a significant component of technical feasibility, in that time is an inherent factor in bringing any advanced technology from research to widespread production. In the TSD, EPA discussed lead time in the context of specific technologies (such as Atkinson cycle engine technology) as well as in the context of general technical feasibility of the MY2022-2025 standards.

Some commenters on the Draft TAR made general allusions to the perceived difficulty of meeting the 2022-2025 standards with advanced technologies given the available lead time. In contrast, several NGOs recognized the value and adequacy of the lead time already provided by the standards. In response, EPA pointed out that the standards for MY2022-2025 were first established in 2012, providing the auto manufacturers with up to 13 years of lead time for product planning to meet these standards, representing multiple vehicle redesign cycles that provide opportunities for technology introduction. EPA also cited ongoing evidence of the increasingly rapid pace at which manufacturers are bringing advanced technologies into the fleet, to the extent that technology adoption rates and the pace of innovation have accelerated even beyond what EPA projected when initially setting these standards. EPA also pointed out that the technologies considered in the Draft TAR and Proposed Determination analyses are either currently in production or will be commercially produced in the next several years. More discussion may be found in Section IV.B of the Proposed Determination document at p. 48-50, and TSD Chapter 2.3.1.1 at p. 2-207.

Some comments received on the Draft TAR related specifically to the lead time required for introduction of Atkinson cycle engine technology at the penetration rates projected in the Draft TAR. EPA disagreed that introduction of Atkinson cycle technology would require greater lead time than afforded by the time frame of the 2022-2025 standards, pointing out (as discussed in the TSD at p. 2-309 to 2-310) that the steps required to implement an Atkinson cycle engine are relatively modest compared to implementing other engine technologies, and that many of the building blocks are already available in the MY2016 fleet, including gasoline direct injection and high levels of valve train authority (further suggesting that a major vehicle redesign cycle is not necessarily required to introduce this technology). EPA also cited the fact that the technology has been introduced and has undergone several revisions within the past 5 years, suggesting that lead time requirements are not as great as the commenters suggest.

EPA also cited several examples of manufacturers that have either already implemented or have indicated plans to implement forms of Atkinson cycle technology. EPA also noted that the projected technology penetrations of the Draft TAR are meant to illustrate one of many possible technology pathways for compliance, and that manufacturers are free to pursue paths that are less reliant on Atkinson cycle technology if they choose to do so. EPA cited sensitivity analyses that indicated that cost effective compliance paths using primarily other advanced engine technologies exist even when Atkinson cycle technology is limited (i.e. arbitrarily constrained for purpose of the sensitivity analysis) to far lower penetrations. EPA concluded that it is feasible for this technology to be incorporated by any manufacturer and that there is sufficient lead time until MYs 2022-2025 that this technology could represent a significant penetration rate of a company's products, if it chooses to employ this technology. More discussion of these comments can be found in Section IV.B of the Proposed Determination document at p. 48-50, and TSD Chapter 2.3.4.1.8.3 at p. 2-309 to 2-310, as well as in Chapter 2) (Atkinson Cycle Engine) of this RTC document.

Similarly, commenters positing the need for significant penetration of electrified vehicles as a necessary compliance path further stated that there would be inadequate lead time to do so. EPA reiterated that both the Draft TAR and Proposed Determination analyses continue to indicate that relatively low penetrations of strong hybrids or electric vehicles would be needed to comply with the standards, and that there will be adequate lead time for manufacturers to achieve these low levels of penetration. More discussion may be found in Section IV.B of the Proposed Determination document at p. 49.

Summary and Response to Comments on the Proposed Determination

In their comments on the Proposed Determination, the Alliance stated that "EPA's response to technology lead-time and adoption is inadequate and misleading." In their comments, the Alliance disagreed that the promulgation of the 2022-2025 MY standards in calendar year 2012 constitutes the start of the lead time available to meet said standards. The Alliance further commented that many of the key technologies considered by EPA for the Proposed Determination are not currently in production. The Alliance specifically identified the non-hybrid application of an Atkinson cycle engine with cooled EGR, cylinder deactivation, higher compression ratio and ability to run on regular gasoline as an example of a key technology. The comments further contend that single examples of technology do not reflect the wide diversity of products produced and sold in the U.S.

In response, EPA notes that the Alliance and many of its members have commented at length about the extensive research and development and capital investments required to meet future GHG standards, while at the same time commenting that the Final Determination could have been delayed by 18 months with no meaningful impact on the industry or the environment.

Assuming a typical 5-year vehicle design cycle followed by a 5-year production life, most if not all of the vehicle program cycles that have completed design and development to date will have turned over prior to MY2025, with only the most recently initiated design and development programs likely to produce vehicles that will be part of the MY2025 fleet EPA believes it is appropriate to consider the promulgation of the standards in the 2012 FRM as a legitimate starting point, and has provided the auto industry with a considerable amount of lead time.

Comments from the Alliance stated that insufficient lead time was available to implement a non-hybrid Atkinson cycle implementation with high compression ratio, cooled EGR, and cylinder deactivation. Similarly, Global Automakers commented that lead time to introduce a new technology typically includes substantial time for initial development and integration prior to introduction, and specifically criticized the example of Mazda's introduction of Atkinson cycle engines as not including the time Mazda would have required to develop and integrate the engine into its vehicle lineup. In response, EPA notes that the first manufacturer to implement an advanced technology typically faces the greatest burden of resolving fundamental uncertainties and evaluating viable approaches for implementing the technology, following a line of inquiry that is also likely to be the subject of other researchers in the field at about the same time. Subsequent applications of this technology cannot be expected to entail the same degree of investment and risk in their development and integration, particularly now that production Atkinson cycle engines are available for study and experimentation. EPA has provided additional response regarding the lead time for this technology in Chapter 2.5.1 of this RTC document.

Global Automakers also commented that EPA was "prioritizing a single set of engine technologies" by modeling the Atkinson 2 package as having significant projected penetration, and requested an explanation of why EPA had "chosen to emphasize one technology over another." In response, we note that EPA models technologies on a performance basis, and judges their feasibility with respect to its assessment of the state of technology development. As stated above and in the Proposed Determination, it is our assessment that Atkinson cycle technology is a feasible option for compliance with the MY2022-2025 standards, in part due to the observation that the steps required to implement it have become relatively modest with respect to the building blocks already present in much of the MY2016 fleet. Projected technology penetrations are a result of how a given technology competes with other available technologies for inclusion in the cost-minimizing compliance fleet, and is therefore a result of the fleet compliance analysis as a whole and is not the result of any specific prioritization or emphasis. In addition, for the Proposed Determination EPA conducted a sensitivity analysis by artificially constraining Atkinson 2 technology to 10 percent penetration. This sensitivity demonstrated that cost-effective compliance paths using primarily other advanced gasoline engine technologies continue to exist even under this scenario, at only modestly increased costs (see Section C.1.2.1.4 of the Proposed Determination Appendix at p. A-144 and p. A-147). EPA further discusses comments relating Atkinson 2 technology in Chapter 2.5.1 of this RTC document.

General Motors commented that the Novation Analytics analysis performed for the Alliance indicates that meeting the MY2025 standards would require the rate of improvement in engine efficiency to increase to a rate double that of historical rates, and characterized this pace of innovation as "unrealistic and unsubstantiated." GM further points to EPA's powertrain efficiency projections in the TSD as being close to the necessary rate of improvement reported by Novation. EPA disagrees that the rate of improvement reported in the TSD is unrealistic or unsubstantiated. We note that the adoption of technology-forcing standards would be expected to lead to an increase in the rate of innovation. As we noted in Chapter 4.1.3 of the TSD at p. 4-8, "in the absence of a forcing mechanism such as regulation … manufacturers may prefer smaller, incremental innovations," due in part to factors such as risk and uncertainty. Thus, historical rates from a period without technology-forcing standards would not be expected to represent the realistic potential pace of innovation under new standards. Figure 25 in the Novation report[28] illustrates this, appearing to show a faster rate of improvement in powertrain efficiency from 2012-2014 (when the MY2012-2016 standards came into effect) than from 2005-2012 (a period of flat regulatory stringency). In fact, the depicted rate of improvement appears to be similar to or possibly greater than the 0.7 percent rate that Novation cites and which the commenter considers unrealistic. Chapter 6 of the 2016 EPA Trends Report, which tracks technology adoption across the industry as well as by individual manufacturers, also shows that the historical fleet-average rate of technology adoption tends to mask the fact that individual manufacturers often achieve high penetration rates of a technology very quickly (following the first application of the technology by that manufacturer). The implication is that if some regulatory or market force incentivized manufacturers to begin adopting technology at the same time, then the fleet average would respond much more rapidly than the historical trend would suggest. Therefore, EPA disagrees that historical rates of improvement are an accurate reflection of rates of innovation that would apply to a time frame influenced by greater than historical stringency.

2.5 Individual Technologies

2.5.1 Atkinson Cycle Engine

Summary of Comments on the Draft TAR addressed in the Proposed Determination

Appendix A.2.3.1 of the Proposed Determination and Chapter 2.3.4.1.8 of the TSD discuss the Atkinson Cycle engine technology, particularly as applied to non-hybrid vehicle applications. The TSD discussion includes an overview of the comments EPA received on this topic in the Draft TAR and EPA's responses to those comments.

Comments received on EPA's Draft TAR assessment of Atkinson Cycle engines in non-hybrid applications were primarily focused on the effectiveness estimates, asserting that EPA's evaluation of the technology was overly optimistic. Specifically, the commenters stated that in practice there are limitations of cooled exhaust gas recirculation (cEGR) for knock prevention, that EPA's torque curve was incorrect, and that manufacturers do not have sufficient lead time to adopt the technology at the penetration rates projected in EPA's compliance analysis. EPA's responses in the Proposed Determination TSD Chapter 2.3.4.1.8.1 and TSD Appendix D described the justification for the cEGR effectiveness benefits, and provide additional clarification regarding an apparent misinterpretation by the commenters of materials published and presented publicly by EPA. Those responses also indicate that the Atkinson Cycle architecture, enhanced with cEGR and cylinder deactivation (DEAC) and with a higher compression ratio, is already demonstrated both domestically (by both Mazda and VW) and in Japan and Europe. EPA noted that engine modeling and initial hardware testing appear to show synergies between the use of cEGR and DEAC with Atkinson Cycle engines. See TSD Chapter 2.3.4.1.4. TSD Appendix D also presented fuel differentiation maps documenting the minimal effects of using different fuels (including a comparison of the technology's effectiveness when

[28] Novation Analytics, "Technology Effectiveness – Phase I: Fleet-Level Assessment (Version 1.1)", October 19, 2015. Submitted to EPA Docket EPA-HQ_OAR-2015-0827.

using Tier 2 and Tier 3 fuels). EPA also noted that commenters had failed to provide any data, or description, of why DEAC could not be applied in conjunction with cEGR on Atkinson cycle engines. Id. Chapter 2.3.4.1.8.3 of the PD TSD provided additional detail regarding the specific design changes which manufacturers could use to adopt Atkinson engine technology (should they decide to follow a compliance path that includes it).

With respect to the issue of lead time, EPA noted that many of the building blocks necessary to operate an engine in Atkinson mode are already present in the 2016 fleet, including gasoline direct injection (GDI), increased valve phasing authority, higher compression ratios, and (in some instances) cEGR. EPA also explained that some of the potential packaging obstacles mentioned in the comments, such as exhaust manifold design, should not be an impediment because more conventional manifold designs (not requiring a revamping of vehicle architecture) are both available and demonstrated in Atkinson Cycle applications. We responded that there is sufficient lead time before MY2022 to adopt the technology and that it could be incorporated without needing to be part of a major vehicle redesign. In addition, and as explained in the Proposed Determination Appendix C.1.2.1.4 and TSD Chapter 2.3.4.1.8.3, EPA conducted sensitivity analyses constraining penetration of Atkinson-cycle engines and found that there are other cost-effective compliance paths available which rely chiefly on advanced gasoline technologies, and that a compliance path that includes lower penetrations of Atkinson cycle engine technology need not result in high penetrations of electrification.

Summary of Comments on the Proposed Determination

EPA received several comments relating to our discussion of Atkinson Cycle engine technologies in the Proposed Determination. In general, we received these same comments on the Draft TAR, and we addressed them in the Proposed Determination Appendix and TSD as stated above. In addition, we received the following new comments on the Proposed Determination:

- Atkinson 2 (ATK2)[29] penetration rate change from Draft TAR to Proposed Determination (Toyota)
- Comments on several different aspects of Atkinson Cycle engine technologies including technology benefits, lead time, and technology adoption rates (Alliance)
- Lack of a full-scale assessment of the research and development and manufacturing costs that would be required to convert to this [Atkinson] engine technology (Global)
- ATK2 far less effective than EPA's predictions and not been sufficiently validated in commercial production (FCA)
- ATK2 effectiveness with cEGR should be significantly higher than what was used by EPA (ICCT)

Where appropriate, comments relating specifically to the issue of lead time for Atkinson cycle technology were addressed in Chapter 0 of this Response to Comments document.

[29] Atkinson 2 represents the application of Atkinson cycle engine operation in a conventional (i.e. non-hybrid) powertrain architecture. See Appendix to the Proposed Determination A.2.3.1 at p. A-6.

Response to Comments on the Proposed Determination

Toyota maintained that although the technology is deployed in approximately 7 percent of the current fleet (consistent with EPA's estimates), the technology actually does not operate that much of the time in Atkinson mode due to issues of control and power limitations without providing any substantiating data. Toyota further stated (without supporting reference) that the technology was insufficient to meet 2025 target levels. In response, EPA benchmarking of the Mazda SKYACTIV-G using both chassis dynamometer and engine dynamometer testing confirmed substantial use of Atkinson mode, particularly in areas of operation important for compliance over the regulatory drive cycles. Some of this can be seen in the contour plot of effective compression versus engine speed and torque in Figure 2.15 of the TSD which shows a significant degree of Atkinson operation even at fairly high loads (e.g., peak effective compression ratio of 11:1 vs. expansion ratio of 13:1) and illustrates how reduced effective compression ratio is used during part-load operation of this engine to reduce the need for throttling and reduce part-load pumping losses. Section 2.3.3.4 of the TSD also briefly summarizes and cites a peer-reviewed EPA paper (SAE 2016-01-1007) that evaluated a Mazda SKYACTIV-G engine using engine dynamometer hardware-in-the-loop (HIL) simulation of vehicle operation. When the engine was evaluated during engine dynamometer testing using HIL simulation of D-segment mid-size passenger car with a footprint of approximately 48 ft^2, an advanced 8-speed transmission, and moderate levels of road load reduction, the CO_2 emissions results were consistent with compliance with MY2025 GHG standards after application of AC credit and with no further application of advanced engine technology beyond that of the 2014 Mazda SKYACTIV-G.[30]

The Alliance commented on several aspects of Atkinson engine technologies including technology benefits, lead time, and technology adoption rates. The Alliance commented that EPA had either disregarded its similar comments on the Draft TAR or had provided an inadequate response. Contrary to the Alliance's assertions, each of these topics raised by the Alliance in their comments on the draft TAR and again in their comments on the Proposed Determination was carefully considered by EPA in the Proposed Determination analysis, and each topic was fully addressed in responses to comments in the Proposed Determination document and the TSD. See the Proposed Determination Appendix Section A.2.3.1 beginning at p. A-7 and C.1.1.3.2 at A-132, and TSD Chapter 2.3.4.1.8.1 at p. 2-299 through 2-308.

In topic #22 of their comments, the Alliance confounds the ability to adopt Atkinson technology with the effectiveness of the technology. The Alliance stated that EPA's response "oversimplifies the requirements of introducing complex engine architectures to a large portion of the new vehicle fleet." The Alliance then references a presentation made by Mazda regarding the importance of the 4-2-1 exhaust system to the overall performance of the SkyActiv technology and required packaging coordination with the SkyActiv Body. In response, EPA recognizes the importance of the 4-2-1 exhaust system to the SkyActiv/Atkinson implementation and also recognizes that the packaging of the exhaust system will require coordination with ancillary vehicle systems. However, these types of packaging coordination activities are part of the routine design and integration process for vehicle manufacturers, and these types of activities

[30] Ellies, B., Schenk, C., and Dekraker, P., "Benchmarking and Hardware-in-the-Loop Operation of a 2014 MAZDA SkyActiv 2.0L 13:1 Compression Ratio Engine," SAE Technical Paper 2016-01-1007, 2016, doi:10.4271/2016-01 1007.

are required independent of the technology pathway that each manufacturer has chosen. For example, if a manufacturer chooses to implement a downsized turbo-charged engine in lieu of a naturally aspirated Atkinson engine with 4-2-1 exhaust, the vehicle manufacturer will need to adopt thermal management, exhaust manifold packaging, and NVH controls that will also require coordination with the body, interior and electrical systems. Likewise, a manufacturer choosing to adopt a cylinder deactivation solution will also require coordination with body and chassis systems to avoid deteriorated NVH performance. EPA believes that the Atkinson technology is not unique in its vehicle coordination requirements and that the Alliance has provided no supporting data to support a different conclusion. On slide 17 of the same presentation referenced by the Alliance, Mazda in fact discusses that the 4-2-1 technology is not new, and while it did cause some challenges, Mazda was able to engineer robust solutions and package the technology into very compact spaces, (e.g., Mazda2/Toyota Yaris, Mazda CX-3).

With regard to the benefits of Atkinson technology, the Alliance commented that EPA has not yet demonstrated the projected benefit of an Atkinson cycle engine with cooled EGR and cylinder deactivation and that EPA did not provide physical test results with a combination of Atkinson, cooled EGR, and cylinder deactivation. In addition, the Alliance noted that there are no current examples of Atkinson cycle engines being produced with cooled EGR and cylinder deactivation. EPA's response to these comments remains unchanged from our response to comments on the Draft TAR. Note the summary of our responses to those comments above and the associated references. EPA provided physical engine dynamometer test results using a combination of Atkinson Cycle and cooled EGR and results from engine testing conducted using cooled EGR and Atkinson Cycle with physical deactivation of two out of four cylinders. Results were presented in TSD Chapter 2.3.4.1.8.1 of the Proposed Determination and showed that effectiveness used within the Lumped Parameter Model for this combination of technologies was conservative relative to engine dynamometer test data. Data with cylinder deactivation was also compared with published data from Mazda for one of their developmental engines using cylinder deactivation.

The Alliance commented that many key technologies were not currently in production, e.g. non-hybrid Atkinson cycle engines with higher compression ratio, cooled EGR, and cylinder deactivation. This is similar to comments provided by the Alliance to the Draft TAR and EPA responded in TSD Chapter 2.3.4.1.3 of the Proposed Determination (see in particular p. 2-290). In response, EPA notes that Mazda presented data at the 2015 Vienna Motor Symposium from a SKYACTIV-G engine with a cylinder deactivation system at an advanced stage of development. The engine demonstrated effectiveness comparable to EPA estimates for applying cylinder deactivation to ATK2 and comparable to EPA engine dynamometer testing of the SKYACTIV-G with 2 cylinders disabled. Mazda has used cooled EGR with previous production applications of their SKYACTIV-G engine, currently uses cooled EGR in the SKYACTIV Turbo engine in the 2017 Mazda CX9, and cooled EGR is currently used by Toyota and Hyundai in Atkinson Cycle engines for both hybrid electric vehicle (HEV) and in non-HEV applications. At the 2017 North American International Auto Show, Toyota announced that the base engine in the redesigned 2018 Toyota Camry would be Toyota's 2.5L I4 Dynamic Force Engine with a peak brake thermal efficiency of 40%. The Toyota 2.5L I4 Dynamic Force Engine engine combines Atkinson Cycle with cooled EGR and a dual PFI/GDI fuel injection system. In 2016, Toyota's Camry model was the best-selling mid-size passenger car in the U.S. VW has already introduced a 4-cylinder Miller Cycle engine, the EA211 TSI® evo, which combines cylinder deactivation, cooled EGR, early intake valve closing, and turbocharging. Miller Cycle is essentially a boosted version of Atkinson Cycle.

Finally, with respect to the projected rates of adoption of Atkinson technologies, the Alliance commented that EPA had not addressed the concern with auto manufacturers that had already invested in other alternatives. The Alliance speculated that EPA was "unable or unwilling to refute the Alliance's broader concerns directly." On the contrary, EPA believes that there is sufficient time for companies to deploy the Atkinson technology should they wish to do so since the technology can be implemented as a developmental extension of existing, current-production engine hardware (e.g., GDI, dual camshaft phasing with high authority, increased intake port tumble) in use in a large percentage of vehicles. As stated in the Proposed Determination, many of the underlying technologies required to operate an engine in Atkinson mode are already in production in many vehicles, including GDI, high authority valve trains, and higher compression ratios. See also the discussion of lead time in Chapter 0 of this Response to Comments document.

In addition, EPA's analysis shows that there are other cost-effective pathways to compliance not heavily reliant on either ATK2 or electrification available for companies wishing to pursue them, whether for reasons of commitment of resources or for marketing response. In an effort to quantify the effects of different technology pathways, EPA conducted several sensitivity analyses, including a scenario in which Atkinson penetration was capped at 10 percent, and a scenario with reduced penetration of mass reduction. See Proposed Determination Appendix C.1.2.1.4. Overall projected cost did not vary significantly across these scenarios, ranging from a low of $800 per vehicle across the fleet (primary analysis) to a high of $1,115 (still less than projected in the 2012 FRM, a cost that the agencies found to be reasonable). Despite the artificial constraints on certain technologies, including Atkinson, the overall cost of compliance remains stable across these different pathways. EPA believes that these sensitivity analyses directly respond to the Alliance's concern regarding vehicle manufacturers that have chosen a compliance pathway that is different from that identified in the Proposed Determination. As vehicle manufacturers choose among alternative pathways, EPA does not believe that their costs will be significantly different from those projected in the Proposed Determination.

Global Automakers noted "the lack of a full-scale assessment of the research and development and manufacturing costs that would be required to convert to this [Atkinson] engine technology" and further suggested that more lead time would be needed to adopt it, pointing out that Mazda had spent time developing and integrating the engine into its vehicle lineup which EPA had not taken into consideration. These comments seem to be grounded in the assumption that EPA has determined that Atkinson cycle technology is the only technology that will allow the vehicle manufacturers to meet the future standards and that the EPA analysis and projected technology penetrations are prescriptive. As previously stated in the Draft TAR and the Proposed Determination, EPA believes that Atkinson cycle technology is one of several cost effective powertrain alternatives available to vehicle manufacturers to meet the MY2025 standards. In EPA's analysis we have added technology in a cost effective manner to establish future compliance (i.e., projected technology penetrations are a result of how a given technology competes with other available technologies for inclusion in the cost-minimizing compliance fleet). If a vehicle manufacturer is pursuing an alternative pathway for compliance, the EPA analysis does not force a manufacturer into a different compliance solution, and the research, development and manufacturing costs of conversion to an alternative pathway are not required.

Honda maintained that larger engine displacement would be needed to deal with issues of power loss and torque recovery. Use of a broad range of camshaft phasing authority and GDI allows the degree of Atkinson Cycle to be varied across the speed and load range of the engine. In Mazda's implementation of Atkinson Cycle with GDI as a replacement for PFI engines, peak torque and rated power were improved relative to their PFI predecessors at the same cylinder displacement. For example, when the Mazda 2.5L SKYACTIV-G engines replaced the previous 2.5L PFI MZR L5-VE engines in the Mazda3 and Mazda6, peak torque increased from 225 N-m to 251 N-m and rated power increased from 125 kW to 138 kW. Peak torque for the 2.5L SKYACTIV-G engine was also available at considerably lower engine speed than its PFI predecessor (3250 rpm vs. 4500 rpm, respectively). As described in TSD 2.3.4.1.8.1, EPA increased engine displacement by 5% in analyses used for the Proposed Determination for all "advanced" ATK2 engine packages to which a 1-point increase in geometric CR and cEGR are applied. This was done to reflect a reduction in peak BMEP and a resultant necessity for increased engine displacement to maintain vehicle acceleration performance and was done to maintain a conservative assessment of "advanced" ATK2 effectiveness. This adjustment resulted in a decrease in LPM CO_2 effectiveness for the proposed determination relative to the Draft TAR of approximately 0.1 to 0.65%, with the range roughly coinciding with low and high power-to-weight-ratio vehicles, respectively.

FCA commented that their own extensive internal analysis showed ATK2 to be far less effective than EPA's predictions and also stated that ATK2 had not been sufficiently validated in commercial production. The comments are identical to comments provided by FCA on the Draft TAR and do not take into consideration EPA's response to the original comments, nor the engine dynamometer and chassis dynamometer test data generated by EPA and summarized within the Proposed Determination TSD showing that EPA's modeled effectiveness is conservative. FCA did not provide engine dynamometer data, chassis dynamometer data, or modeling data to support a lower effectiveness for ATK2.

ICCT comments cite a technology report on non-HEV Atkinson Cycle engines that estimates effectiveness to be approximately double the effectiveness used by EPA for ATK2 with the addition of cooled EGR in the proposed determination. ICCT also found that EPA's reported effectiveness had reduced by approximately 3 to 5 percent for ATK2 with cooled EGR between the Draft TAR and the Proposed Determination. ICCT based their estimate of 12.5 percent effectiveness of ATK2 with cooled EGR in part on effectiveness derived from public data from Mazda, Toyota, and Hyundai. In response, EPA notes that it is difficult to isolate individual technology effectiveness as opposed to the effectiveness of a combination of technologies that are part of an overall vehicle package. Atkinson Cycle effectiveness is also somewhat sensitive to vehicle road load, transmission gear ratio spread and number of gears, all of which were accounted for in EPA's ALPHA modeling. Based on ALPHA modeling results, we also would not expect ATK2 to have identical effectiveness regardless of vehicle class. The effectiveness by vehicle class shown by ICCT between the Draft TAR and the Proposed Determination directly compares vehicle classes that are close to one another but that are not truly identical. Some variation in effectiveness between the Draft TAR and Proposed Determination analyses may also be due to differences in the combination of technologies applied to specific vehicle packages rather than significant differences in ATK2 effectiveness between the two analyses. Engine displacements for ATK2 with cooled EGR were increased by 5 percent between the Draft TAR and the Proposed Determination in part in response to comments received from vehicle manufacturers regarding maintaining equivalent vehicle performance during operation on 87 AKI in-use regular-grade gasolines. EPA estimates the impact of this change on CO_2 effectiveness to be significantly less than 1 percent, or considerably less than the 3 to 5 percent differences reported by ICCT.

2.5.2 Turbo Downsizing

Summary of Comments on the Draft TAR addressed in the Proposed Determination

Appendix A.2.3.2 of the Proposed Determination and Chapters 2.3.3.3.8 and 2.3.4.1.9 of the TSD discussed engine turbo downsizing (TDS) technology. The discussion EPA provided in the TSD included an overview of the comments EPA received on this topic in the Draft TAR and EPA's responses to those comments. Comments received on the EPA's Draft TAR assessment of turbocharged/downsized engines were primarily focused on the following topics:

- Choice of the Ricardo EGRB research engine as representative of 2025 turbocharged/downsized engine technology instead of the 2010 Ford 1.6L EcoBoost or 2014 Ford 2.7L EcoBoost engines
- The impacts of octane and relative CO_2 effectiveness during operation of Tier 2 certification gasoline vs. Tier 3 certification gasoline or in-use regular-grade 87AKI E10 gasoline, including presentation of the Alliance data from mid-level (E20, E30) ethanol blended gasoline at different octane levels to represent impacts from E0 or E10 gasoline at different octane levels
- The relative benefits of cEGR
- Impacts of differences in crevice volume
- Discussion of displacement/vehicle-mass (D/M) as a market-acceptance metric for engine downsizing

EPA's responses in the Proposed Determination TSD Chapter 2.3.4.1.9.1 described the justification for using the Ricardo EGRB V6 engine as the basis for evaluating turbocharged/downsized engine effectiveness, explained the unrepresentative nature of the fuels used in the study cited by the Alliance, and summarized CO_2 emissions from EPA chassis dynamometer testing of vehicles with turbocharged/downsized engines and other engine types using Tier 2 E0 96 RON gasoline and Tier 3 E10 87 RON gasoline. EPA responses to comments regarding crevice volumes and cEGR use are also included in TSD Chapter 2.3.4.1.9.1. EPA's responses in the Proposed Determination TSD Chapter 2.3.3.3.8 discussed D/M of turbocharged/downsized engines, including D/M in current vehicle applications and current market acceptability of vehicles with D/M of less than 0.9.

Summary of Comments on the Proposed Determination

The Alliance commented on several aspects of turbo downsized technology starting with a broad statement that EPA's assessment of gasoline turbocharged direct injection engines was optimistic. The Alliance supported their comments through several comparisons including a comparison of EPA's 1.17 L GTDI TDS24 engine configuration and the turbo downsized, GDI engine applied by NHTSA in its Draft TAR analysis, and a comparison of the same EPA engine to the current Ford 2.7L Eco Boost engine.

Toyota commented that they had not received a response to questions regarding the rationale for why 27 bar BMEP turbocharging was not analyzed as part of the Draft TAR or Proposed Determination.

Response to Comments on the Proposed Determination

Regarding the inclusion of 27-bar peak BMEP turbocharged/downsized engines in the FRM and limiting peak BMEP to 24-bar in the Draft TAR and Proposed Determination, EPA found only a small incremental effectiveness improvement between 24-bar and 27-bar BMEP engines with both engines using cooled EGR. The boosting requirements for 27-bar peak BMEP also necessitated a more complex and higher cost boosting system relative to 24-bar BMEP (i.e., use of sequential turbocharging at 27-bar BMEP as opposed to VNT at 24-bar BMEP). Engines with 24-bar peak BMEP have more potential for friction reduction than would be possible at 27-bar peak BMEP due to the cylinder pressures required for higher BMEP and resultant connecting rod and main bearing loads. EPA still expects turbocharged/downsized engines exceeding 24-bar peak BMEP in the MY2022-2025 timeframe, particularly in limited production high-performance vehicles and in some cases with the addition of variable compression ratio. Such engines are already at an advanced stage of development or entering production (e.g., 2017 Honda Civic Type R, 2018 Infiniti QX50).

The Alliance's comments regarding EPA data described future, advanced turbocharged/downsized engines such as TDS24 as having 10-20 percent lower fuel flow than either the Ford Ecoboost 2.7L engine or the 24-bar BMEP turbocharged GDI engine modeled by a subcontractor to Argonne National Laboratories (ANL) for NHTSA's Draft TAR analysis. The Alliance described those particular areas of operation where the fuel flow differences were greatest as important regions of operation over the regulatory drive cycles and thus the EPA results were characterized by the Alliance as overly optimistic and not plausible.

Differences in fuel consumption or CO_2 emissions between these types of engines are not entirely surprising considering the different levels of engine technologies applied. Please refer to the discussion of engine technology differences between the Ford Ecoboost 2.7L engine and TDS24 in the response to Alliance comments to the Draft TAR in Chapter 2.3.4.1.9.1 of the TSD. The TSD also included comparisons of data from both the TDS24 and the Ford 2.7L Ecoboost engines with publicly available data from advanced turbocharged/downsized engines from MY2017 VW and Honda light-duty vehicles. The EPA analyses and comparisons using the VW and Honda turbocharged/downsized engines were not considered within the Alliance analysis despite the fact that these current production engines are somewhat closer to EPA TDS24 with respect to engine technology than the 2015 Ford Ecoboost 2.7L.

In considering the Alliance comments regarding EPA's modeling of drive-cycle CO_2 emissions from advanced turbocharged/downsized engines, we compared TDS24, the Alliance-referenced ANL 24-bar BMEP configuration, the Ford Ecoboost 2.7L, and the three additional turbocharged/downsized engines mentioned in the Proposed Determination (VW EA211-evo and EA888-3B, and the Honda L15B7) using ALPHA simulations of a vehicle configuration similar to what was used within ALPHA simulation results provided by the Alliance in their comments to the Proposed Determination. As stated previously in the TSD, these three additional engines reflect more modern applications of engine technology by automobile manufacturers than the Ford Ecoboost 2.7L. While still lacking some of the more advanced features of TDS24 (e.g., VVL, dual high/low pressure loop cEGR, centrally-mounted high-pressure piezo fuel injection), all three engines achieve comparable or higher efficiency over regions of engine operation that are important for compliance with CO_2 emissions standards. Two of the engines (VW EA211-evo and EA888-3B) used Miller Cycle. One of the engines (VW EA211-evo) also uses 2/4-cylinder deactivation, a VNT turbocharger and a third generation of high-pressure (350-bar) direct fuel injection. The engines are also part of a growing trend towards moderate to significantly higher stroke to bore ratio (S/B), which improves combustion thermodynamics and in-cylinder turbulence generation. The EA211-evo and Honda L15B7 have S/B of 1.15 and 1.22, respectively, while the older Ford Ecoboost 2.7L design uses a S/B of 1.0.

The engines were all scaled to provide approximately equivalent torque between 1000 and 3500 rpm to TDS24 and equivalent vehicle performance for a low power-to-weight ratio, high road-load (LPW-HRL) vehicle configuration similar to a CUV. This vehicle configuration was chosen to be approximately comparable to the vehicle configuration summarized by the Alliance within Table 1 of their comments on the Proposed Determination. Table 2-4 appearing below summarizes the vehicle, engine and transmission combinations analyzed. The vehicle configurations with turbocharged/downsized engines were also compared to an exemplar vehicle with a 2.38 L naturally aspirated GDI engine and 6-speed automatic transmission to reflect an approximately MY2015 level of technology. The examples with turbocharged/downsized engines were configured with advanced 8-speed automatic transmissions, a 5% reduction in vehicle mass, and 10% reductions in rolling resistance and aerodynamic drag to reflect a moderate level of road load reduction for compliance with 2022-2025 LD GHG standards.

An initial analysis looked at fuel usage for a region of operation identified by the Alliance in its comments as important for compliance over the drive cycle. This region of operation within the Alliance's analysis showed 10-20% fuel differences and represented operation of TDS24 at below 2-bar BMEP or approximately 19 N-m of torque (see the Alliance comments on Proposed Determination, Figure 3). Figure 2-7 and Figure 2-8 show the contribution of mass of fuel consumed at different torque points (i.e., torque at all speeds) encountered over the combined FTP and HwFET cycles as well as cumulative fuel usage over the combined cycles for 1.17L TDS24 and a Ford 2.7L Ecoboost scaled for equivalent performance (1.24L 3-cylinder). Operation over the regulatory cycles at less than 19 N-m of torque accounted for less than 4% of fuel used by TSD24 and less than 7% of fuel used by the Ford Ecoboost 2.7, and thus the sub-19 N-m region of operation with 10-20% fuel consumption differences would account for a difference of approximately 1% over the drive cycle.

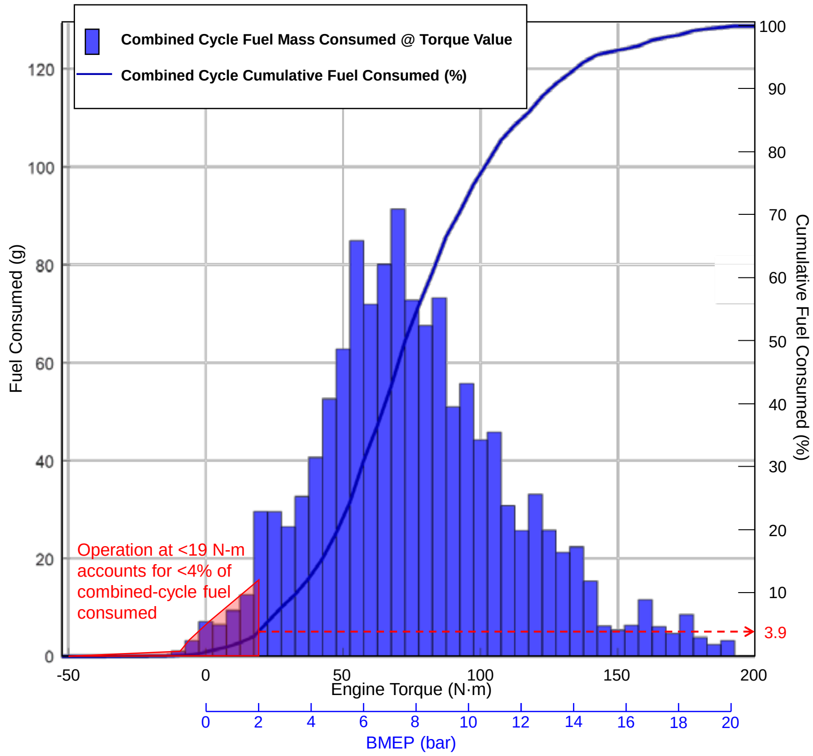


Figure 2-7 EPA TDS24 1.17L I3 Combined Cycle Fuel Consumption Distribution vs. Engine Torque

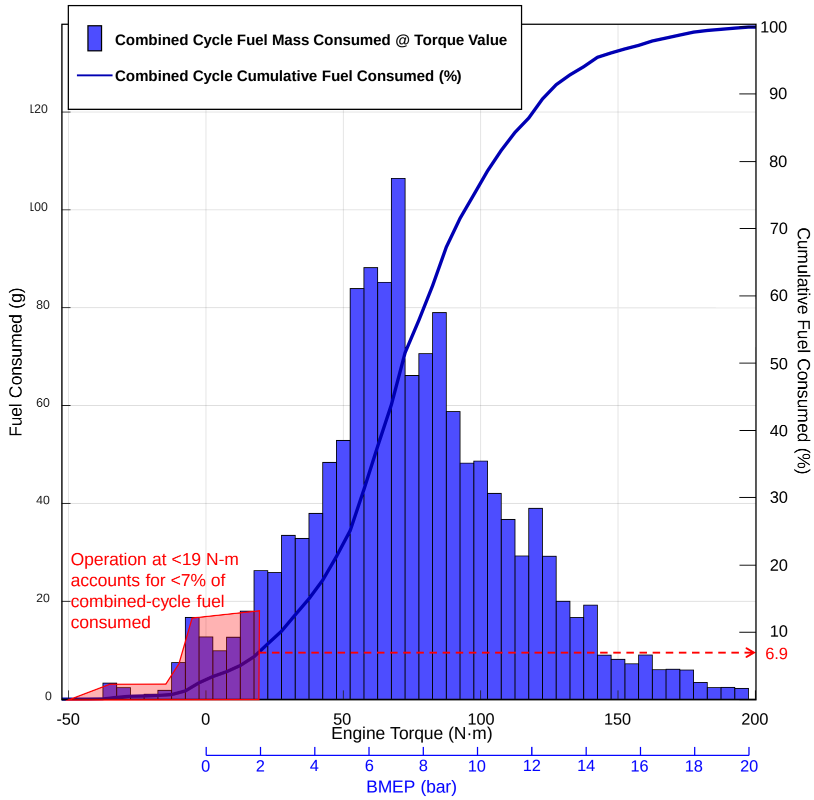


Figure 2-8 Ford Ecoboost 2.7L Scaled to 1.24L I3 Combined Cycle Fuel Consumption Distribution vs. Engine Torque

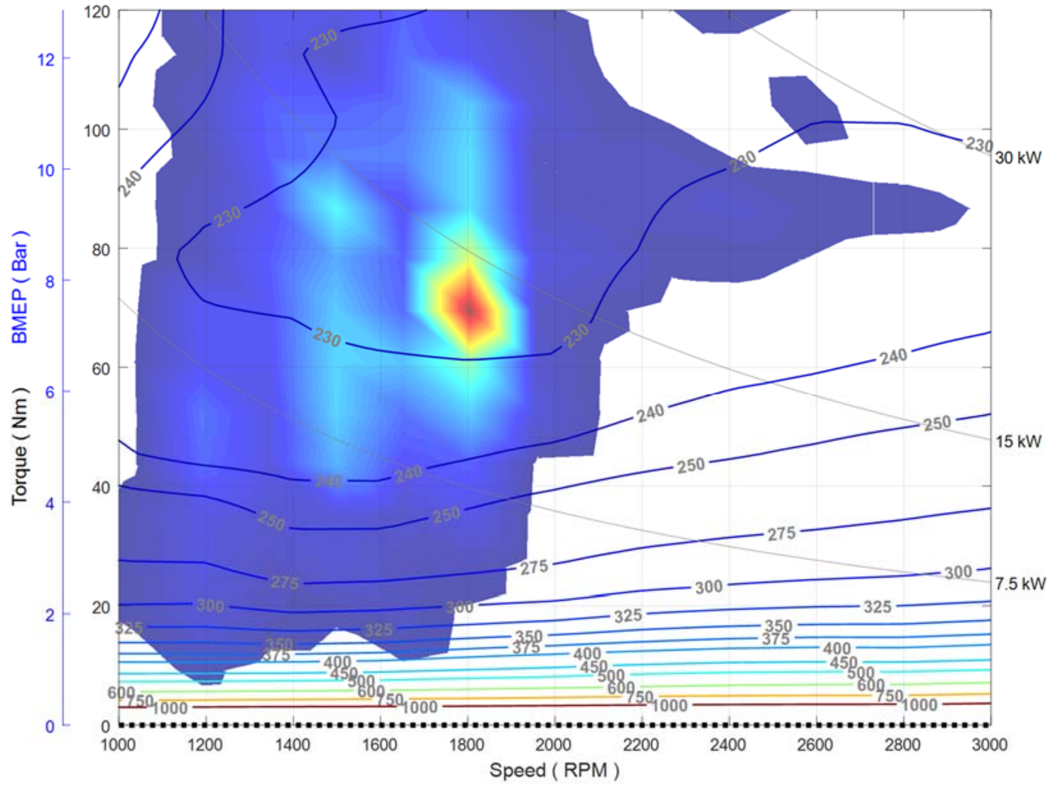


Figure 2-9 BSFC and Combined-Cycle Fuel Consumption "Heat Map" for the EPA TDS24 1.17L I3.

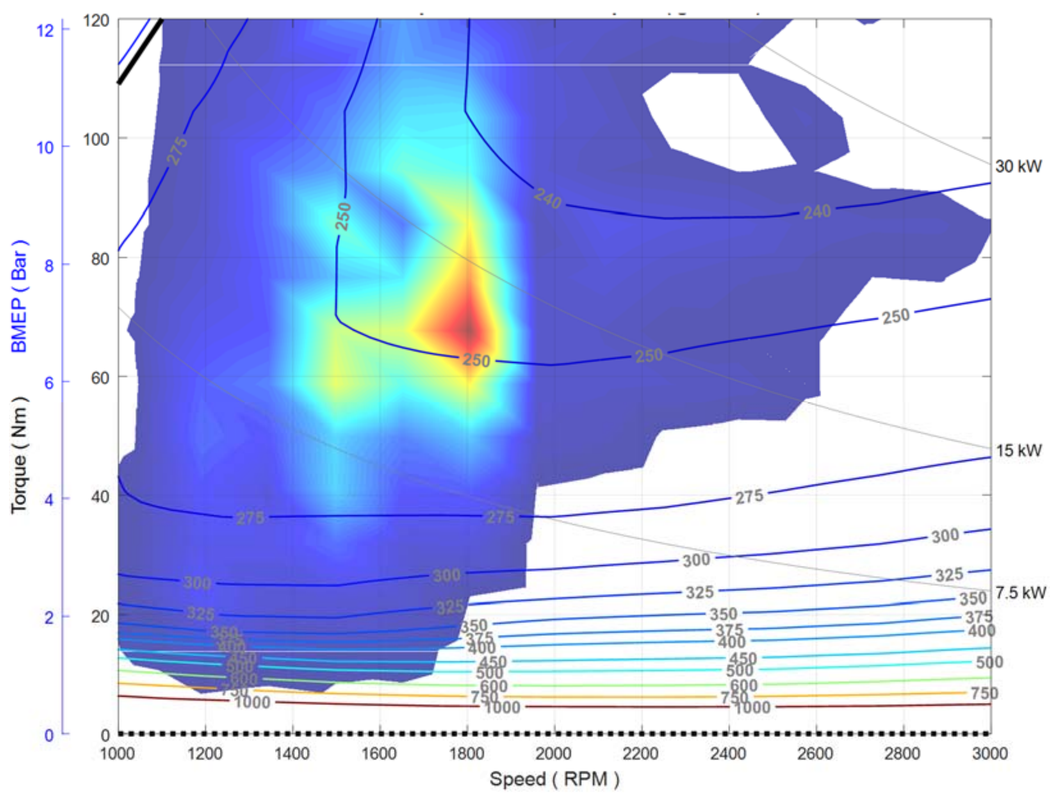


Figure 2-10 BSFC and Combined-Cycle Fuel Consumption "Heat Map" for the Ford Ecoboost 2.7L scaled to a 1.24L I3.

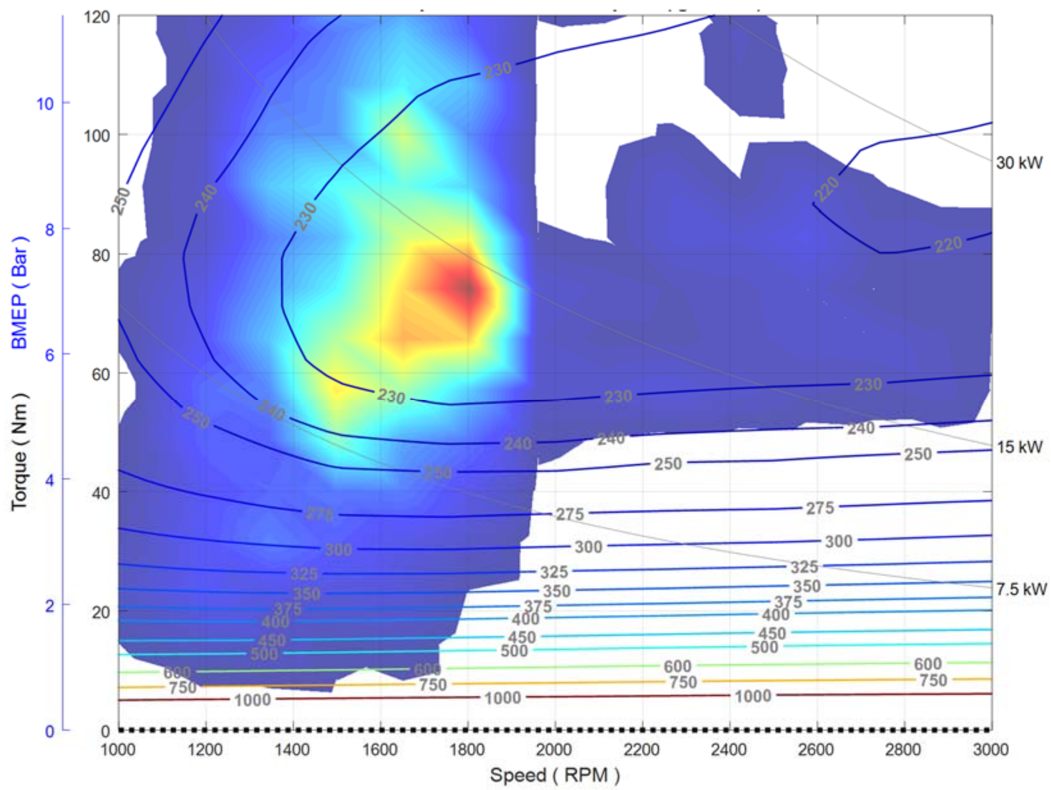


Figure 2-11 BSFC and Combined-Cycle Fuel Consumption "Heat Map" for the Honda L15B7 scaled to a 1.32L I3.

Uncertainty in fuel flow measurements increases at very light loads due to the resulting low fuel flow rates. Relatively small differences in differences in fuel flow measured at light-load (i.e., low-flow) conditions appear large on a percentage basis even if absolute differences are small and even if such operating conditions do not represent a significant contribution to cycle-integrated fuel consumption or CO_2 emissions. The relative importance of different speed/load conditions on fuel consumed over the drive cycles can be visualized using "heat maps" such as those shown in Figure 2-9, Figure 2-10, and Figure 2-11 for TDS24, and the scaled Ford Ecoboost 2.7L and Honda L15B7 engine configurations, respectively. Please note that the heat maps were plotted over the same 1000-3000 rpm and sub-120 N-m torque operational range shown within Figure 2 and Figure 3 of the Alliance comments to the Proposed Determination and do not reflect the full range of engine operation. The "heat maps" indicate that fuel consumption differences at higher load conditions than those identified by the Alliance (e.g., from approximately 40 N-m to approximately 110 N-m torque) would be significantly more important with respect to drive cycle fuel consumption and CO_2 emissions than operation at less than 19 N-m of torque for the specific examples shown here and within the Alliance comments to the Proposed Determination.

Figure 2-12 and Figure 2-13 are EPA's recreation of Figure 2 and Figure 3, respectively, from the Alliance comments to the Proposed Determination showing fuel consumption differences between 1000 – 3000 rpm and below 120 N-m of torque. Figure 2-12 shows a comparisons of the EPA TDS24 and the Honda L15B7 to the ANL 24-bar BMEP engine and Figure 2-13 compares the TDS24 and the Honda L15B7 to a scaled version of the Ford 2.7L Ecoboost.

When properly scaling the engines for equivalent torque, EPA's analysis found somewhat larger differences at light loads between TDS24 and the scaled Ford Ecoboost 2.7L and significantly larger differences relative to the ANL 24-bar configurations. Comparing the scaled Honda L15B7 engine to the scaled Ford Ecoboost 2.7L and the ANL 24-bar configuration showed remarkably similar differences to those found with the comparison to TDS24 despite the Honda engine's lack of some of the technologies used for TDS24 (e.g., cEGR, VVL and VNT).

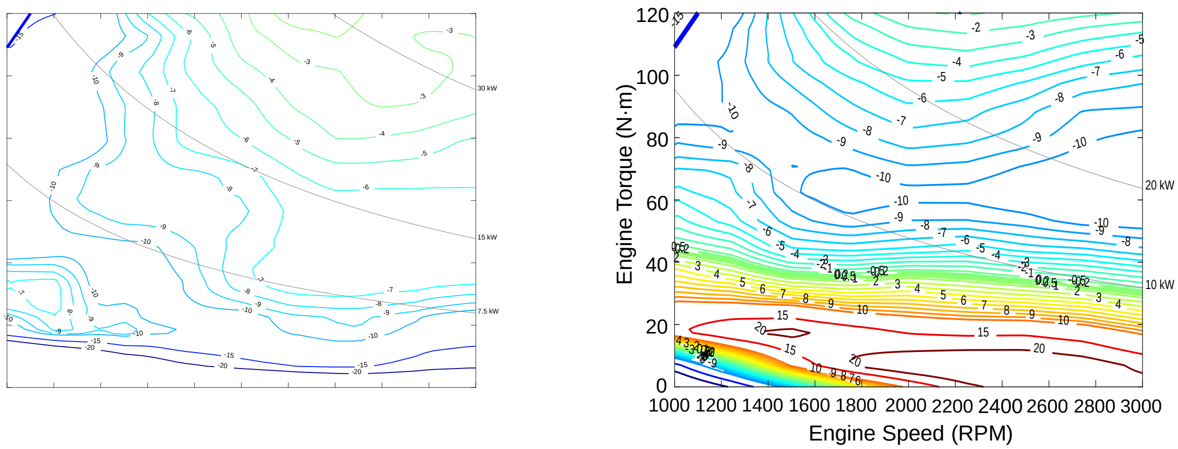


Figure 2-12 Percentage Differences in Fuel Consumption Between The 1.17L TDS24 and the MY2015 Ford Ecoboost 2.7L Engines (left) and between the MY2017 Honda L15B7 and the MY2015 Ford Ecoboost 2.7L Engines.

Note: Technology used by TDS24 but not used in the MY2015 Ford Ecoboost 2.7L includes higher pressure, centrally-mounted piezo fuel injection; variable valve lift; VNT turbocharging; cooled low and high pressure external EGR; and higher cylinder pressure capability. Technology used by the MY2017 Honda L15B7 TDS24 but not used in the MY2015 Ford Ecoboost 2.7L includes higher pressure solenoid fuel injection, improved S/B ratio (~1.2) for reduced thermal losses and increased intake port tumble for improved combustion phasing. Both the Ford Ecoboost 2.7L and the Honda L15B7 have large ranges (≥ 50 °CAD) of both intake and exhaust cam phasing authority, but EPA benchmarking of both engines shows a larger range cam phasing, particularly at light load, for the Honda L15B7.

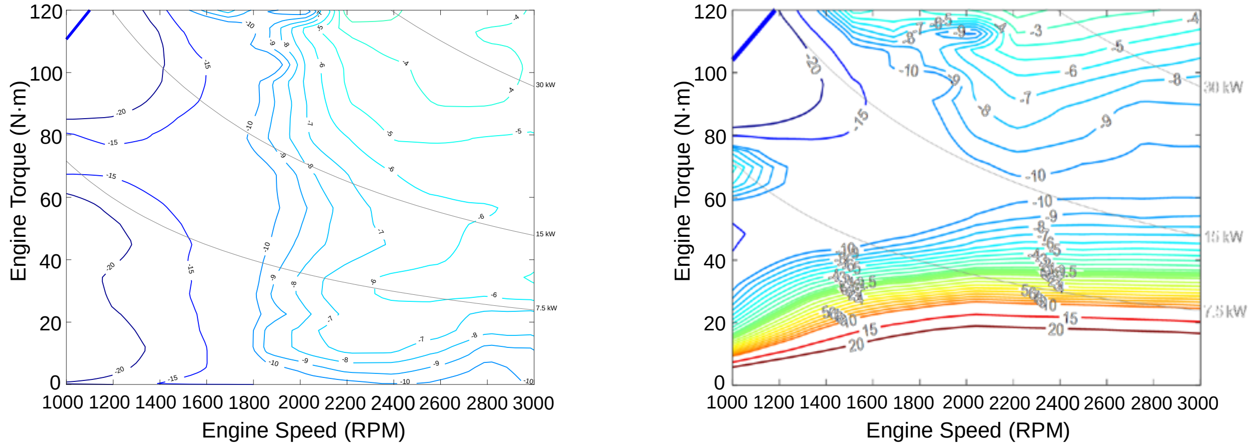


Figure 2-13 Percentage Differences in Fuel Consumption Between the 1.17L TDS24 and the ANL 24-Bar BMEP Engine Configuration (left) and between the MY2017 Honda L15B7 and the ANL 24-Bar BMEP Engine Configuration.

Note: Technology used by TDS24 but not used in the ANL 24-Bar BMEP engine configuration includes higher pressure, centrally-mounted piezo fuel injection; wider control authority for camshaft phasing; VNT turbocharging; integrated exhaust manifold, and an additional cooled low pressure external EGR loop; Technology used by the MY2017 Honda L15B7 TDS24 but not used in the ANL 24-Bar BMEP engine configuration includes higher pressure solenoid fuel injection, wider control authority for camshaft phasing, improved S/B ratio (~1.2) for reduced thermal losses and increased intake port tumble for improved combustion phasing.

The CO_2 emissions results for a LPW-HRL ALPHA vehicle simulations using six turbocharged downsized engines and a naturally-aspirated GDI exemplar configuration are summarized in Table 2-4.The EPA TDS24 showed a 3.3% improvement relative to the Honda engine and approximately equivalent combined cycle CO_2 emissions relative to the VW engines when comparing ALPHA simulations without start-stop. The EPA TDS24 had a 14.4% combined cycle CO_2 reduction relative to the ANL 24-Bar BMEP engine and a 9.4% CO_2 reduction relative to the Ford 2.7L Ecoboost. The EPA simulation results with start-stop active showed approximately equivalent results for the EPA TDS24, Honda L15B7, VW EA211-evo, and VW EA888-3B, with EPA TDS24 having 14.2% and 7.5% CO_2 reductions relative to the scaled ANL 24-bar and Ford 2.7L Ecoboost, respectively.

As was found with the fuel consumption difference maps, the differences in CO_2 emissions from ALPHA vehicle simulations between the scaled Honda L15B7 and either the scaled Ford 2.7L Ecoboost or the ANL 24-bar configurations were comparable to differences relative to EPA TDS24. The Honda L15B7 had a 11.4% combined cycle CO_2 reduction relative to the ANL 24-Bar BMEP configuration and a 6.3% CO_2 reduction relative to the Ford Ecoboost 2.7L when compared without start/stop. The EPA simulation results with start-stop active showed that the Honda L15B7 had CO_2 reductions of 12.8% and 6.1% relative to the Ford Ecoboost 2.7L and ANL 24-Bar BMEP configuration. Again, the Honda L15B7 engine to the scaled Ford Ecoboost 2.7L and the ANL 24-bar configuration showed remarkably similar simulation results to those found with the EPA TDS24 despite the Honda engine's lack of some of the technologies used for TDS24 (e.g., higher BMEP, cEGR, VVL and VNT). Some of this may be due to the improved S/B and increased variation of intake cam phasing (although similar levels of authority) for the Honda engine relative to TDS24. Both the ALPHA simulation results and the BSFC maps of the

2017 VW and Honda engines show that CO_2 emissions comparable to TDS24 can be achieved with the most recently developed production turbocharged/downsized engines and with less application of advanced gasoline SI engine technology than projected for TDS24. TheCO_2 vehicle modeling results achieved with TDS24 turbocharged downsized engines are not only plausible, but are conservative. With application of further technologies (e.g., cEGR, VVL and VNT) to recently developed engines like the Honda L15B7 engine, CO_2 effectiveness would likely be improved relative to EPA TDS24.

Table 2-4 ALPHA Model Inputs and Results for a LPW-HRL Vehicle Type (e.g., CUV).

Road load reductions reflecting a 5% reduction and vehicle mass and 10% reductions in aerodynamic drag and rolling resistance were applied to the turbocharged/downsized vehicle configurations.

Engine (basis)	Base 2.5L I4	2017 VW EA211-fevo	2017 VW EA888-3B	2015 Ford 2.7L Ecoboost	2017 Honda L15B7 (CRV)	ANL 24-Bar BMEP Turbo GDI	EPA TDS24
Engine Technology	NA, GDI, DCP	GDI Turbo (17-bar BMEP), IEM, DCP, Miller Cycle, cEGR, DEAC (2/4), 350-bar solenoid FI	GDI Turbo (20-bar BMEP, IEM, DCP, Miller Cycle	GDI Turbo (24-bar BMEP), IEM, DCP	GDI Turbo (20-bar BMEP), IEM, DCP (>50° intake cam auth.)	GDI Turbo (24-bar BMEP), DCP, DVVL, HP cEGR	GDI Turbo (24-bar BMEP), IEM, DCP (50° intake cam auth.), CVVL, HP/LP cEGR, 350-bar piezo FI
Displacement After Scaling (L)	2.38	1.65	1.49	1.24	1.32	1.16	1.17
# Cylinders After Scaling	4	4	4	3	3	3	3
ETW	3855	3677	3677	3677	3677	3677	3677
Road Load Coefficients A	34.95	29.364045	29.364045	029.364045	29.364045	29.364045	29.364045
B	0.0875	0.0875	0.0875	0.0875	0.0875	0.0875	0.0875
C	0.02526	0.022734	0.022734	0.022734	0.022734	0.022734	0.022734
HP @ 50 MPH	13.66	12.08	12.08	12.08	12.08	12.08	12.08
Transmission	TRX11 6-sp. Auto.	TRX22 8-Sp. Auto	TRX22 8-Sp. Auto	TRX22 8-Sp. Auto	TRX22 8-Sp. Auto	TRX22 8-Sp. Auto	TRX22 8-Sp. Auto
Gear Ratio Spread	3.785 -0.616	5.501 -0.632	5.501 -0.632	5.501 -0.632	5.501 -0.632	5.501 -0.632	5.501 -0.632
Final Drive Ratio	3.73	3.51	3.68	3.95	3.86	4.11	4.02
CO2 (Combined, w/o start-stop)	281.4	198.9	197.5	217.2	203.5	229.8	196.7
TDS24 % CO2 difference w/o start-stop	-30.1%	-1.1%	-0.4%	-9.4%	-3.3%	-14.4%	----
CO2 (With Truck AC Credit, w/o start-stop)	257.0	174.5	173.1	192.8	179.1	205.4	172.3
CO2 (Combined, w/ start-stop)	274.7	195.8	195.0	211.6	198.7	227.9	195.6
TDS24 % CO2 difference w/ start-stop	-28.8%	-0.1%	0.3%	-7.5%	-1.6%	-14.2%	----
CO2 (With Truck AC Credit, w/ start-stop)	250.3	171.4	170.6	187.2	174.3	203.5	171.2

2.5.3 Other Engine Technologies (Cylinder Deactivation, Cam Phasing, Variable Valve Lift)

Summary of Comments on the Draft TAR addressed in the Proposed Determination

TSD Chapter 2.3.4.1 included a discussion of valvetrain technologies. The TSD discussion included an overview of the comments EPA received on this topic in the Draft TAR and EPA's responses to those comments. Comments received on EPA's Draft TAR assessment of valvetrain technologies were primarily focused on the following topics:

- Cylinder deactivation (DEAC) effectiveness, operational area, and appropriateness of using cEGR with DEAC
- The effectiveness of intake cam phasing (ICP) and dual cam phasing (DCP)
- The effectiveness of discrete variable valve lift (DVVL), and continuously variable valve lift (CVVL)

EPA's responses in the Proposed Determination TSD Chapter 2.3.4.1.3 described the justification for fixed-cylinder DEAC effectiveness and summarized the current production GM application of cylinder deactivation used by EPA as a source of data for the operating range and degree of activation of DEAC. EPA's responses in the Proposed Determination TSD Chapter 2.3.4.1.3 also provided current production examples of light-duty vehicle applications using cEGR and Atkinson Cycle and a combination of cEGR, DEAC and early intake valve closing. EPA's responses regarding the effectiveness of other valvetrain technologies were summarized in TSD Chapters 2.3.4.1.4 through 2.3.4.1.7 and are supported by peer-reviewed published data.

Summary of Comments on the Proposed Determination

EPA received several comments relating to our discussion of valvetrain technologies in the Proposed Determination. With the following exceptions, we received these same comments on the Draft TAR, and we addressed them in the TSD as stated above.

Toyota suggested that several other technologies which have not yet been commercialized, such as the combination of Atkinson 2 with high compression ratio, cooled EGR, electric boosting, dynamic cylinder deactivation, and variable compression ratio, will likely be part of the ongoing conventional ICE improvements and questioned whether they would be sufficient to meet the 2022-2025 model year standards.

ICCT commented that several key technologies were not modeled, including e-boost, variable compression ratio, and dynamic cylinder deactivation, and provided a series of citations in which these technologies were examined in the public domain. It emphasized that "the single most important factor in the accuracy of cost and benefit for projections is the use of the latest, most up to date technology data and developments", and indicated that compliance costs would be overstated without considering the most recently available technology developments.

MEMA claimed that EPA did not respond to its initial comment to the Draft TAR that EPA revisit light-duty diesel data and analysis in the Final Determination. It pointed to a white paper published by MARTEC as a source of updated information regarding light-duty diesel effectiveness and cost estimates.

Similarly, MECA "believes that light-duty diesel powertrains provide a cost-effective, durable approach for vehicle manufacturers to improve the average fuel economy of their fleets, particularly in the larger power category that includes small pick-up trucks and SUVs."

UCS commented that while EPA estimated an effectiveness for fixed cylinder deactivation of 3.9 to 5.3 percent in the Draft TAR, its application in the OMEGA and Lumped Parameter models "seems to fall consistently below this range." It also commented that EPA's exclusion of dynamic cylinder deactivation from its effectiveness analysis is too conservative.

Response to Comments on the Proposed Determination

Regarding Toyota's comment questioning the ability of conventional ICE technologies to meet 2022-2025 standards, EPA acknowledges that some manufacturers may choose increased hybridization and electrification as a compliance strategy that best suits their current positioning in the marketplace. Based on its extensive modeling of all current and emerging technologies expected to be commercialized, EPA illustrated in the Draft TAR one technical pathway (of many that exist) that it believes to be cost-effective. Ultimately it will be up to the manufacturers to determine the compliance strategy that best complements their future vehicle lineup.

In response to ICCT's comments on new technologies not considered, EPA acknowledges that technologies continue to emerge in the marketplace; however, both detailed modeling of the physical systems, as well as a rigorous cost assessment (e.g. teardown analysis), are required to consider these technologies with the same level of robustness as the other technologies reviewed in the Draft TAR. EPA agrees that including additional emerging technologies, when supported by a rigorous performance and cost assessment, could provide even greater flexibility and potentially lower compliance costs than the array of technologies already represented, and acknowledges that its assessment might be conservative absent their inclusion in its analysis.

In response to MECA's and MEMA's comments concerning diesel powertrains: EPA reviewed the MARTEC report. The MARTEC report reviews light-duty diesel efficiency and fuel consumption improvements relative to advanced gasoline engines, but it does not take into consideration the CO_2 emissions control effectiveness of light-duty diesels. The carbon content of diesel fuel is higher than gasoline on both a volumetric and mass basis. On a volumetric basis, diesel fuel combustion emits 10.18 kg of CO_2 per gallon versus 8.887 kg of CO_2 per gallon of gasoline[31], which results in a 14.5% CO_2 penalty for diesels relative to spark ignition gasoline-fueled vehicles at equivalent fuel economy. Thus while vehicles with diesel engines generally have improved fuel economy and thermal efficiency relative to vehicles with advanced gasoline engines, vehicles with advanced gasoline engines can have comparable CO_2 emissions due to the reduced carbon content of gasoline relative to diesel fuel.

EPA also carefully considered new light-duty diesel engine technology developments that have occurred after the FRM and the NRC diesel analysis. Chapter 5.2.2.11 of the Draft TAR and Chapter 2.2.2.11 of the TSD to the Proposed Determination discuss the basis used for determining the effectiveness of advanced light-duty diesel engines. The Lumped Parameter Model and OMEGA were updated to take into account the CO_2 effectiveness of Tier 3 compliant light-duty diesels using dual-mode PCCI/diffusional combustion, higher peak BMEP, and

[31] Diesel fuel CO2 emissions factor is from Title 40 CFR § 600.113. Gasoline CO2 emissions factor is from 75 FR 25324, May 7, 2010.

advanced boosting systems based on data developed as part of the U.S. DOE and Cummins ATLAS Research and Development Program. As part of an analysis for the Draft TAR, EPA also commissioned a detailed tear-down study of a Tier 2-compliant light-duty VW diesel engine. Approximately halfway through the study, both EPA and California compliance actions determined that the engine used for the tear-down study was noncompliant with Tier 2 emissions standards. The investigation of light-duty diesel compliance with federal emissions regulations was also underway throughout the development of the Proposed Determination and is still ongoing. While we agree with MECA's comments that light-duty diesels can continue to comply with future emissions standards, the ongoing investigation complicates our ability to determine an accurate bill of materials and costs for a truly Tier 3 compliant diesel emissions control system. Furthermore, EPA's OMEGA results and the relative lack of diesel technology should not be interpreted as an indictment of diesel technology. EPA fully expects that manufacturers will continue to produce diesels for the US market and will do so because they have determined that diesel technology provides them a more cost effective path to compliance than that estimated by our OMEGA runs and because of the operational advantages of light-duty diesel engines in specific applications (e.g., sustained high-load conditions from operation at high loaded vehicle weights and/or loaded trailer weights in heavy-light-duty trucks and MDPVs).

In response to UCS's comments about cylinder deactivation, EPA notes that in Chapter 2.3.4.1.3 of the TSD, EPA addressed the effectiveness of fixed cylinder deactivation, its appropriateness in the context of several independent estimates, and its exclusion of rolling dynamic cylinder deactivation in the Proposed Determination. More importantly, the individual incremental effectiveness of any given technology (when incorporated into a vehicle technology package within the Lumped Parameter model) is entirely dependent upon the other technologies simultaneously applied to the vehicle. Frequently, technologies will provide a lower incremental effectiveness than they would if they were applied to a vehicle with no other advanced technologies present, due to the synergistic effects of multiple technologies addressing the same physical losses.

2.5.4 Transmissions

Summary of Comments on the Draft TAR addressed in the Proposed Determination

Appendix A.2.4 of the Proposed Determination and Chapter 2.3.4.2 of the TSD discussed transmission technology. The TSD discussion addressed the comments EPA received on this topic in the Draft TAR.

Commenters questioned the way EPA had assessed and classified automated transmissions in the Draft TAR. The Draft TAR mapped all types of automated transmissions to a consistent TRX[32] transmission level. Commenters claimed the TRX designations were unnecessarily complicated and did not recognize unique efficiencies of different transmission technologies. EPA's responses in the TSD Chapter 2.3.4.2.1 noted that the TRX binning system was created in response to industry comments, which correctly pointed out that transmission choice is based on market and functional objectives, which may not always be the same as the most cost-effective transmission selected by the OMEGA model. The TRX designations allow EPA to maintain the type of transmission technology found in the baseline fleet during OMEGA modeling - which

[32] TRX is a shorthand term EPA uses to designate transmission technology levels.

reflects the market and functional objectives - rather than allowing the OMEGA model to default to a seemingly more cost-effective transmission solution. Put another way, the TRX designation implicitly assumes that manufacturers will likely maintain the transmission type already in the baseline fleet for a specific vehicle, consistent with stakeholder comments. EPA acknowledged that different transmissions have unique effectiveness, but stated that the effectiveness gains between TRX levels will be similar (see TSD Fig. 2-116), and did not consider the additional CO_2 benefit gained from changing transmission type in its analysis. The agency's ultimate finding on this issue was that the TRX classification system provided a reasonable means of assessing technology cost and effectiveness while maintaining maximum manufacturer flexibility.

Commenters also questioned the CVT effectiveness value EPA used in the Draft TAR, specifically disagreeing with EPA's expectation for potential future effectiveness increases in CVTs. In response to these comments, EPA in the Proposed Determination assumed that CVTs would be aligned with a more advanced transmission type (in the TRX classification scheme, CVTs would be classified as TRX21), a conservative assumption because it results in much of the potential transmission improvement being included within the baseline (unlike the approach in the Draft TAR, which classified CVTs in the baseline fleet as less advanced (TRX11)). Thus, the classification used in the TSD recognizes fewer efficiency improvements to meet potential standards. See TSD Chapters 2.3.4.2.1 and 2.3.4.2.2.

A comment from the Alliance disagreed with EPA's Draft TAR assessment of the effectiveness of TRX11 transmissions. No further information was provided, but EPA documented its basis for TRX11 effectiveness values in the TSD Chapter 2.3.4.2.2, and stands behind its documented analysis.

Commenters also questioned the relative values for front- and rear-wheel drive transmission effectiveness used by EPA in the Draft TAR. Specifically, commenters stated that packaging difficulties in front wheel drive transmissions tend to increase spin and churning losses. EPA's response in the TSD Chapter 2.3.4.2.2 clarifies that additional losses associated with the differential were included when modeling transmissions.

A comment on EPA's Draft TAR assessment of transmission efficiency stated that industry progress on transmission efficiency should be appropriately quantified in the baseline fleet. EPA's response in the TSD Chapter 2.3.4.2.2 described how we quantified transmission efficiency using baseline fleet transmissions. In addition, as explained above, in response to Draft TAR comments on CVT effectiveness, in the Proposed Determination EPA reclassified CVTs within the baseline as the more advanced TRX21. TSD Chapter 2.3.4.2.1 provided additional information on the assumptions EPA made in the assessment of transmission technology in the baseline fleet.

Comments on EPA's Draft TAR assessment of transmission efficiency stated that EPA's estimated effectiveness differences between current six- and eight-speed transmissions were high. These comments included reference to modeling results by Ford, and an assessment of simulation differences between the EPA and Ford simulations. Chapter 2.3.4.2.2 of the TSD and the Proposed Determination Appendix A.2.4 provide a discussion of these differences (among other things, Ford assumed a gradeability metric which EPA believes is both inappropriate for advanced eight-speed transmissions, and not necessarily present in production vehicles ostensibly designed to meet that metric), and why EPA regards the simulation results as corroborative.

Comments on EPA's Draft TAR assessment of transmission efficiency and transmission modeling stated that top gear gradeability should be maintained as a performance metric when implementing advanced transmissions. EPA's responses in the TSD Chapter 2.3.4.2.2 provide additional discussion that manufacturers are not currently maintaining top gear gradeability due to the inherent advantages of advanced transmissions. Further discussion of comments received on gradeability in the TSD is in Chapter 2.2.5 of this Response to Comments document.

Commenters also stated that manufacturers expected only marginal improvements due to HEG2[33] (i.e., the additional effectiveness gain from TRX21 to TRX22), presenting an example from FCA. EPA's responses in the TSD Chapter 2.3.4.2.3 and in the Proposed Determination Appendix A.2.4 provide additional detail regarding corroboration of the HEG2 effectiveness values, a discussion of the portion of HEG2 technologies represented by the FCA example (indicating, among other things, that the FCA example reflected a partial use of the technology and so was not optimized, and that efficiency values quoted by transmission suppliers are consistent with those obtained by EPA), and why this information is consistent with EPA's assumptions.

Summary and Response to Comments on the Proposed Determination

EPA received comments from stakeholders on effectiveness values assigned to transmission technology. Specifically, General Motors stated that "after conducting the in-depth technology analysis of the Silverado pickup and Malibu midsize car ... EPA errors are apparent, the most notable being overstated fuel economy improvements attributable to transmission and/or gearbox improvements." EPA acknowledges receiving comments claimed as confidential business information (CBI) under 40 CFR Part 2 from General Motors detailing this in-depth technology analysis. EPA considered this CBI information and believes the improvements attributed by General Motors to transmission improvements are conservative, and do not reflect the same extent of technology development used by EPA in TRX21 and TRX22 transmission packages. Consequently, EPA stands by its analysis.

Additionally, FCA commented that "EPA's Lumped Parameter Model for the 2012 Rule predicted approximately 13% improvements in 8-speed transmission efficiency over baseline for all vehicle types. In the Draft TAR, the Lumped Parameter Model predicted an 8-speed efficiency improvement of 30% for all vehicle types. In the Proposed Determination, however, EPA's Lumped Parameter Model predicted improvements ranging from 28% to 55%." EPA is unable to determine the basis for the commenter's assertion of 28-55% improvement. In the TSD Chapter 2.3.4.2.3 (Table 2.85), the effectiveness associated with progressing from one TRX level to another is presented. However, the average value of efficiency improvement from TRX11 to TRX22 (representing moving from a nominal current six-speed transmission to an advanced eight-speed transmission) is 13 percent, and does not reach 55 percent.

[33] High Efficiency Gearbox technology level 2.

FCA furthermore referred to EPA's testing of 5- and 8-speed Dodge Chargers in 2015 and the SAE paper written detailing this testing and the associated analysis.[34] The average value of 13 percent noted above is somewhat higher than the testing and analysis performed by EPA in 2015 (and referenced in the TSD and in FCA's comments) might suggest. However, the testing and analysis included a number of conservative assumptions as detailed in the paper; for example, the ALPHA modeling used as a basis for transmission efficiency projections predicted about 1 percent lower CO_2 reduction than realized by the tested 8-speed Charger. In addition, since 2015 and through the TSD, EPA has continued to update its transmission data and ALPHA model with the latest data available, as (for example) including the effect of a fast transmission warmup within the TRX22 effectiveness numbers. Consequently, EPA stands by its analysis used to inform the TSD, and believes it represents the best estimation of transmission effectiveness available.

In commenting on disparities in vehicle-level transmission effectiveness between that predicted by EPA's testing and the Lumped Parameter Model, FCA also notes, correctly, that part of the difference between EPA's analysis of potential effectiveness improvements associated with advanced transmissions is associated with corresponding engine downsizing to maintain performance neutrality, and suggests that EPA dismissed comments on the Draft TAR that criticized this approach. EPA clearly explained its rationale regarding this approach to maintaining performance neutrality in the TSD Chapter 2.3.1.2, where we reviewed the philosophical basis for maintaining performance neutrality, which was strongly supported by the National Academy of Sciences -- that technology comparisons should be made on the basis of equivalent acceleration performance, such that the cost-effectiveness values of competing technologies can be fairly compared.

The Alliance of Automobile Manufacturers also commented that EPA dismissed the Ford "Transmission Walk" simulation, included as an attachment and referenced by the Alliance in their comments on the Draft TAR. The attachment referred to by the Alliance walks through a series of simulations to identify discrepancies between the respective technology assumptions made by EPA and Ford. Contrary to the Alliance's statement, EPA believes that the simulations are generally effective at identifying the differences between EPA's transmission technology assumptions and Ford's transmission technology assumptions. However, as stated in Chapter 2.3.4.2.2 of the TSD, EPA disagreed with the assumptions made by Ford and the Alliance, and continues to stand by its analysis. As there explained, there were important differences between the simulation methodology used by Ford and that used by EPA, including the use of different engines (the Ford simulation used a 2.0L EcoBoost engine, while EPA used a naturally aspirated GDI engine), and differing lockup strategies between transmissions. In addition, the Ford simulation assumed no changes in engine displacement whereas EPA applied a performance-neutral downsizing strategy in its simulation. EPA continues to believe that this analysis (and these differences) account for the difference in effectiveness percentages, since "effectiveness percentages reported for transmissions paired with unimproved engines would be reduced when the same transmission is paired with a more advanced engine." Id. p. 2-330. Moreover, this

[34] Moskalik, A., Hula, A., Barba, D., and Kargul, J., "Investigating the Effect of Advanced Automatic Transmissions on Fuel Consumption Using Vehicle Testing and Modeling," *SAE Int. J. Engines* 9(3):1916-1928, 2016, doi:10.4271/2016-01-1142.

discussion shows that EPA did not 'dismiss' Ford's comments, but carefully considered them and explained why there was a difference in effectiveness estimates.

The Association of Global Automakers, in their comments, stated (p. 28, Global comments) that EPA, in evaluating transmission effectiveness numbers, had used dynamometer tests on two Dodge Chargers with identical powertrains to inform those evaluations, but had failed to identify whether other aspects of these vehicles, which might have had an impact on the testing results, were identical. As noted in the reference given in the TSD,[35] the two vehicles had the same engines, rear end ratios, and tires. Further information on test vehicles and process is contained within the referenced paper.

The Association of Global Automakers also commented on EPA's "continued reliance on DCTs," questioned "the assumptions underlying the percentage of CVT penetration," and commented that EPA is not accounting for "the significant consumer acceptance issues associated with [CVTs]." In response to earlier comments, as noted in Chapter 2.3.4.2.1 of the TSD, EPA has implemented a TRX classification scheme where all conventional ATs (as well as DCTs and CVTs) in the baseline fleet were mapped to three different designations: Null, TRX11 and TRX21. Any future transmission technology improvements are represented by advancement through the TRX transmission levels. EPA assumes that all transmission types can be represented by these TRX levels, so that progression through the levels requires only refinement of a particular transmission, not wholesale movement to another transmission type.

The TRX designation system was implemented in response to earlier industry comments. Those comments pointed out that transmission choice is based on market and functional objectives, and on manufacturers' own analyses of transmission types, as Global commented. Thus, manufacturer's choice of transmission type (CVT, DCT, conventional AT, or AMT) may not always be the same as the most cost-effective transmission selected by the OMEGA model. The TRX designations allow EPA to maintain the type of transmission technology found in the baseline fleet during OMEGA modelling – which reflects the market and functional objectives -- rather than allowing the OMEGA model to default to a more (seemingly) cost-effective transmission solution. Put another way, the TRX designation implicitly assumes that manufacturers will likely maintain the transmission type already in the baseline fleet for a specific vehicle, consistent with stakeholder comments. This designation system was implemented in response to precisely the same concerns about specific transmission technologies raised by Global in their comments.

The Union of Concerned Scientists strongly supported EPA's current classification of transmissions into bins but noted that EPA's decision to classify CVTs in the baseline fleet as TRX21 is clearly a conservative approach (as noted in Chapter 2.3.4.2.1 of the TSD). EPA agrees this is likely a conservative approach; however, comments from stakeholders on the Draft TAR indicate that classifying CVTs in the baseline as TRX21 is more reflective of potential transmission improvement than a TRX22 classification, and thus EPA implemented the current classification of CVTs in the TSD.

[35] Moskalik, A., Hula, A., Barba, D., and Kargul, J., "Investigating the Effect of Advanced Automatic Transmissions on Fuel Consumption Using Vehicle Testing and Modeling," *SAE Int. J. Engines* 9(3):1916-1928, 2016, doi:10.4271/2016-01-1142.

The Association of Global Automakers also noted that in the TSD, EPA makes the statement "technology packages and vehicle classes where DCTs are applicable have been re-evaluated to reflect manufacturers' current choices" but does not provide further explanation. EPA's intention in the Draft TAR and TSD was to emphasize that, in response to comments received, EPA had elected to implement a TRX classification scheme, which implicitly assumes that manufacturers will maintain the transmission type they currently choose to implement.

General Motors commented that EPA's effectiveness estimates fail to account for the impacts of "additional pump loading to accumulators needed to enable engine stop-start, electrical losses associated with electrical auxiliary pumps to provide line pressure while the engine is off, and … vibration damping technologies that allow early Torque Converter Clutch (TCC) lock-up," further stating that these reduce effectiveness by adding inertia to the input side of the transmission. EPA interprets this comment as applying primarily to the effectiveness values assumed for stop-start technology, and addresses this comment in Chapter 2.5.7 of this RTC document.

An anonymous citizen commented that GHG standards "reduce the motivation to produce manual transmission vehicles," even though "true manual transmission cars provide safety advantages that make them more attractive to some consumers," citing for example that they discourage texting while driving and that their mechanical nature means that they cannot be 'hacked.' The citizen continues that "manufacturers should be allowed less stringent fuel standards for true manual transmission cars." EPA addresses this comment in Chapter 3.2 of this RTC document where we examine factors affecting availability of manual transmissions in the market.

2.5.5 Battery Technology / Cost

This chapter reviews comments that relate specifically to battery technology and cost. Comments that relate more specifically to non-battery costs are discussed in Chapter 2.5.6 of this Response to Comments (RTC) document. Comments related to PHEVs and BEVs as GHG-reducing technologies are discussed in RTC Chapter 2.5.10. Discussion of comments that relate to electrification but not to the abovementioned technology issues, such as electrified vehicle penetration rates and similar aspects of the Proposed Determination, may be found in Chapters 2.1 and 2.3 of this RTC document.

Summary of Comments on the Draft TAR addressed in the Proposed Determination

Chapter 2.2.4.5 of the TSD discussed the state of battery technology for electrified vehicles. Chapter 2.3.4.3.7 of the TSD develops battery cost estimates for PHEVs, BEVs, and HEVs, and also discussed many of the comments on the Draft TAR that relate to battery technology.

A number of comments received on the Draft TAR related to EPA's projection of battery costs for BEVs. Comments from two major OEMs appeared to generally support aspects of the projected battery costs, or considered them to appear conservative. Comments from BEV-specific manufacturers described both the projected battery costs and battery sizes as conservative when compared to recent industry trends and forecasts. For example, Tesla Motors stated that they expect to achieve battery costs by 2020 that are far below the 2025 Draft TAR assumptions, and also that the battery capacity assumed necessary to achieve 200 miles of range was overstated (see TSD Chapter 2.3.4.3.7 at p. 2-356 to 2-358).

Comments suggesting that the projected costs and perhaps also the projected sizing for battery packs were conservative, as well as continued collection of information on new products and announcements since the Draft TAR, contributed to EPA's decision to update the projected pack costs and sizes for the Proposed Determination analysis in order to reflect the latest information available. This resulted in generally smaller projected pack sizes that more closely align with production examples and also slightly lower costs per kWh for some packs than assumed in the Draft TAR. More discussion of the observations and perceived trends in battery cost projections which contributed to the decision to update the battery analysis are summarized generally in Section A.2.5 of the Proposed Determination Appendix (at A-12 to A-13) as well as in TSD Chapter 2.3.4.3.7.1 at p. 2-369. The updates and their effect on battery sizing and costs are fully discussed in TSD Chapter 2.3.4.3.7 (Cost of Batteries for xEVs).

Other comments related generally to specific assumptions used for battery pack topology, configuration, and assumed production volumes. EPA addressed these comments with clarifications and additional rationale in TSD 2.3.4.3.7.4 at p. 2-387 to 2-388. In response to other observations found in the comments, EPA also clarified certain aspects of the battery analysis, such as, that packs are constructed of cells specifically designed for the power and energy requirements of the vehicle to which they are assigned, that economies of scale are taken into account on that basis, and that indirect costs associated with research and development are included (see TSD Chapter 2.3.4.3.7 at p. 2-356 to 2-357).

Summary of Comments on the Proposed Determination

EPA received several comments relating to our projection of battery costs in the Proposed Determination. Faraday Future, Union of Concerned Scientists (UCS), and the International Council for Clean Transportation (ICCT) described EPA's projection of electric vehicle costs as being overstated; since these comments can be interpreted as relating to both battery and non-battery costs, they are addressed in Chapter 2.5.10.2 (Battery Electric Vehicles).

Global Automakers made several criticisms of EPA's battery cost analysis, raising issues related to the assumed annual production volume and the references that EPA cited in assessing its battery cost projections, and also suggested that EPA failed to consider cost information that had been provided by manufacturers.

Global stated that EPA's MY2025 battery costs are based on a volume exceeding 400,000 per year, which it contends no individual manufacturer will reach. As stated above, EPA received and responded to comments on the Draft TAR relating to the use of this volume as an input to the battery cost model BatPaC. This comment on production volumes mirrors these previous comments, which EPA addressed in TSD Chapter 2.3.4.3.7.4 at p. 2-388 to 2-389.

Response to Comments on the Proposed Determination

Global also stated that EPA cited only one study and the findings of one manufacturer to support the judgment that its Draft TAR battery cost projections appeared conservative. However, this comment refers to a passage in TSD Chapter 2.2.4.2, which is an overview section that previewed highlights of the detailed sections that follow it, and accordingly is not where the analysis supporting the judgment was described, nor where primary references were cited. TSD Chapter 2.2.4.5.9 examined the Draft TAR battery cost projections with respect to the Nykvist and Nilsson study and the General Motors announcement of battery cell costs for the Chevy Bolt, supplemented by several references for estimating pack costs from cell costs (both the Nykvist and Chevy Bolt references have been widely cited across the industry). The conclusion of this analysis was further supported by discussion of several manufacturer comments received on the Draft TAR, as well as several additional references, which (as described above) were fully described in Section A.2.5 of the Proposed Determination Appendix (at A-12 to A-13) and in TSD Chapter 2.3.4.3.7.1 at p. 2-369. These passages clearly show that EPA did not rely on only one reference, nor were the findings of only one manufacturer extended to the entire industry.

Global also stated that its comments on the Draft TAR, as well as confidential business information (CBI) supplied to the agencies, included examples of actual costs that EPA did not use in its Proposed Determination analysis. This information included projections of cost per ton of CO_2 reduced for BEVs and PHEVs versus non-electric technologies. However, cost per ton of CO_2 reduced is not a source of battery or non-battery cost information, and cannot be used as an input to EPA models, which require battery costs to be specified with respect to total battery capacity and power specifications, and component costs to be specified in terms of peak power and direct manufacturing cost at a specific volume. Similarly, EPA generally cannot directly use CBI as a basis for inputs to a publicly available model, and, to preserve confidentiality, can only use such information on a limited internal basis. On this limited basis, battery costs currently being paid by manufacturers for current-technology battery components are certainly informative, but ultimately are of limited utility considering that the goal is to project battery costs not for today's state of technology and demand situation but for a more optimized and developed industry state in 2022-2025. The General Motors Chevy Bolt disclosure remains the only publicly available and widely cited reference for battery cell costs being paid by a volume manufacturer that are represented by the source as applying to a time frame close to 2022-2025. EPA received no other comments or CBI that included information of this type that could be used as modeling inputs or directly compared with the projected costs of the Draft TAR or Proposed Determination.

2.5.6 Non-battery Technology / Cost

This chapter reviews comments that relate specifically to non-battery technology and cost. Comments related more specifically to battery costs are discussed in Chapter 2.5.5 of this RTC, while comments related to PHEVs and BEVs in general are discussed in RTC Chapter 2.5.10. Discussion of comments that relate to electrification but not to the abovementioned technology issues, such as electrified vehicle penetration rates and similar aspects of the Proposed Determination, may be found in Chapters 2.1 and 2.3 of this RTC document.

Summary of Comments on the Draft TAR addressed in the Proposed Determination

Chapter 2.2.4.3 of the TSD discussed the state of non-battery technology for electrified vehicles. Chapter 2.3.4.3.6 of the TSD discussed comments on the Draft TAR that relate to non-battery technologies and costs.

A number of comments received on the Draft TAR related to EPA's projection of non-battery costs for BEVs. Tesla Motors commented that their projected non-battery component costs are "lower by double-digit percentages in every category versus the 2020 U.S. DRIVE figures considered in the TAR," and that they see "significant room for further cost reductions [within] the regulatory timeline covered in the TAR (2022–2025)." While clarifying that the Draft TAR non-battery costs were not derived from the U.S. DRIVE targets that were mentioned in the

Draft TAR, EPA also noted that more information would be needed to supplement these qualitative comments in order to effectively evaluate the EPA non-battery cost projections with respect to Tesla's experience.

Other comments were received that relate more specifically to battery costs than to non-battery costs, and these are reviewed in Chapter 2.5.5 of this RTC document, while comments that relate more to BEV and PEV overall costs are reviewed in RTC Chapter 2.5.10. No additional comments were received that included sufficiently specific data with which the non-battery costs used in the Draft TAR could be effectively adjusted, either to represent larger or smaller volumes, or more or less optimized development programs (as mentioned by some of the comments).

Summary and Response to Comments on the Proposed Determination

In comments on the Proposed Determination, Faraday Future, Union of Concerned Scientists (UCS), and the International Council for Clean Transportation (ICCT) repeated their position that EPA’s projection of electric vehicle costs is overstated. Since these comments can be interpreted as relating to both battery and non-battery costs (and therefore to overall vehicle cost), they are addressed in Chapter 2.5.10.2 (Battery Electric Vehicles). EPA did not receive additional comment pertaining specifically to non-battery costs, except as addressed as part of the discussion in the previously mentioned chapters.

2.5.7 Stop-Start

Summary of Comments on the Draft TAR addressed in the Proposed Determination

Chapters 2.2.4.4.1 and 2.3.4.3.1 of the TSD discuss stop-start technology. Additional discussion of stop-start technology in the context of the off-cycle credit program is found in Section B.3.4.1 of the Proposed Determination Appendix.

Public comments on the Draft TAR did not directly address the cost or effectiveness values EPA used for modeling stop-start technology in the Draft TAR technology assessment. One comment suggested that the effectiveness of stop-start could be improved beyond the value assumed in the Draft TAR when implemented with a dual energy storage system. EPA addressed this comment in Chapter 2.3.4.3.1 of the TSD, pointing out that EPA had acknowledged the possibility of dual systems but chose to model more standard configurations for which data is more readily available. Some additional comment was received in the context of the off-cycle credit program, relating primarily to the ability of the existing credit values for stop-start to represent increased real-world idle time or potential benefits of 48-volt hybridization. These comments were addressed in Section B.3.4.1 of the Proposed Determination Appendix, in part by pointing out that system effectiveness is also an important factor in relating idle time to achieved benefits, and that systems vary widely in how much of the idle time the engine is actually turned off.

Summary and Response to Comments on the Proposed Determination

As part of its comments on advanced transmissions, General Motors commented that EPA modeling of stop-start technology neglected to account for energy demands related to auxiliary electrical pumps and hydraulic accumulator to maintain line pressure and restart the engine, which were said to result in added inertia to the input side of the transmission and additional losses. In response, it is acknowledged that stop-start may be implemented in a number of ways, some with hydraulic auxiliaries and others without. The choice of auxiliary support may depend in part on specific integration issues, such as NVH attributes of specific vehicle architectures or engines on which the technology is proposed for inclusion, and the ability of the base engine to perform combustion-assisted restart. Although EPA's effectiveness values for start-stop technology in the 2012 FRM were based on simulations, the values used in the Draft TAR and Proposed Determination were based on actual vehicle performance, derived in part from 2-cycle certification test data for the Ford Fusion Stop-Start option, and corroborated by similar data from the Mazda3 iStop, meaning that losses due to auxiliary processes such as torque converter lockup and pumping that are applicable to a stop-start implementation on a 4-cylinder gasoline engine were taken into account when developing the effectiveness values. Potential implementations and the associated losses are likely to vary among manufacturers depending on the specifics of the hardware approach they choose to implement and the needs of the engine and other components with which it is integrated. The comment did not detail the magnitude of the auxiliary losses GM anticipates with its particular implementation or the degree to which it might differ from the production stop-start systems on which EPA based its effectiveness values, and EPA has no evidence that the losses for various implementations that may be found across the future fleet would vary dramatically enough to call these values into question as to their representativeness.

EPA did not receive additional comments on the Proposed Determination that concern modeling of stop-start technology. MEMA submitted comments related to off-cycle credits for 48V stop-start technology. Off-cycle credits are addressed in Chapter 3.9 of this RTC document.

2.5.8 Mild Hybrid (48V)

Summary of Comments on the Draft TAR addressed in the Proposed Determination

Chapters 2.2.4.4.2 and 2.3.4.3.2 of the TSD discuss mild hybrid technology. Chapter 2.3.4.3.2 of the TSD discussed comments on the Draft TAR that relate to this topic and the EPA responses to those comments.

Some of the public comments on the Draft TAR relating to mild hybrids were directed toward the decline in projected penetration of mild hybrids as compared to the 2012 FRM analysis, to which EPA responded by characterizing the difference as a result of interactions among various modeling changes to many technologies across the analysis, and not the result of any *a priori* assumption about the potential for this technology to enter the market. Other commenters suggested that the cost and/or effectiveness values EPA assumed for this technology in the Draft TAR technology assessment were more optimistic than their own respective projections, although these comments were not accompanied by supporting data and therefore could not be evaluated. EPA's efficiency estimates are based on demonstrated performance. In addition, EPA pointed to how efficiencies can increase when 48volt (V) mild hybrid technology is used in combination with other technologies, such as an electric supercharger. Several commenters in fact recommended that EPA more fully recognize 48V hybridization as an enabling technology by accounting for additional flexibilities and synergies that can accompany its introduction. EPA acknowledged that these potential benefits can provide value, although this value is difficult to quantify. A battery supplier commented that battery costs for 48V mild hybrid systems appeared to be overstated compared to their cost projections and assumed learning rates said to be applicable to their own products, to which EPA responded in part by observing that the relatively low current penetration of 48V systems in the U.S. and worldwide continues to lend significant uncertainty to the proper learning rate that should be assumed, and that the rate assumed by EPA represents an appropriate value. More detail on these comments and their responses can be found in Chapter 2.3.4.3.2 of the TSD.

Summary and Response to Comments on the Proposed Determination

In comments on the Proposed Determination, ICCT again commented on the value of investigating synergies between 48V hybridization and e-boost, which can lead to similar costs but higher effectiveness. These comments mirror comments received on the Draft TAR, which included comments relating to potential synergies. EPA addressed these Draft TAR comments in Chapter 2.3.4.3.2 of the TSD at p. 2-337. EPA again acknowledges that 48V hybridization may enable synergies that can lead to improved efficiency of other systems and hence of the powertrain as a whole. However, similar to the rationale presented in TSD Chapter 2.3.4.3.1 at p. 2-335 regarding a recommendation that EPA model a dual-battery stop-start implementation, EPA must reasonably limit the number of variations of technologies considered, in recognition of available data on cost and effectiveness. Both detailed modeling of the physical systems as well as rigorous cost assessment are required to consider additional technologies with the same level of robustness as the technologies EPA already considers. As EPA has noted several times, because we expect that the industry will continue to innovate and develop additional and increasingly effective technologies, we are not able to consider every possible technology combination that manufacturers may ultimately find cost-effective to include in their future compliance paths. For example, as mentioned in Section IV.C of the Proposed Determination at p. 54, EPA has not considered several technologies that are known to be under active development, such as electric boosting, dynamic cylinder deactivation, and variable compression ratio. While including such technologies might reduce projected compliance costs if they prove to be more cost-effective than other technologies currently in the analysis, the lack of inclusion of some of these technologies lends a conservative feature to the analysis supporting the Determination.

The Alliance also commented that EPA asserted that no change is needed to give 48V mild hybrids more off-cycle credit than stop-start. Comments related to off-cycle credits are addressed in Chapter 3.9 of this RTC document.

2.5.9 Strong Hybrid

Summary of Comments on the Draft TAR addressed in the Proposed Determination

Chapters 2.2.4.4.3 and 2.3.4.3.3 of the TSD discuss strong hybrid technology. Chapter 2.3.4.3.3 of the TSD includes discussion of public comments on the Draft TAR that relate to this topic and the EPA responses to those comments.

Public comments on the Draft TAR relating to strong hybrids were primarily directed toward the decision to model strong hybrids without reference to specific architecture (P2 or power split), and the potential for differences in cost and effectiveness of the two architectures. EPA responded to these comments by further describing and clarifying the rationale for this decision, noting in addition that the cost and effectiveness of the two architectures appear to be converging and that opinions continue to vary about their relative attributes. Another commenter agreed with the effectiveness estimates for strong hybrids but described the cost estimates as more optimistic than its own projections, although supporting evidence was not provided. More detail on these comments and their responses can be found in Chapter 2.3.4.3.3 of the TSD.

Summary and Response to Comments on the Proposed Determination

Comments received on the Proposed Determination did not raise additional issues related to modeling of strong hybrid technology other than those EPA has already addressed through its responses to comments received on the Draft TAR.

2.5.10 Plug-in Vehicles

This chapter reviews comments related to battery electric vehicle (BEV) and plug-in hybrid electric vehicle (PHEV) technologies. Comments that relate more specifically to battery- and non-battery technologies that are found on these vehicles are reviewed in Chapters 2.5.5 and 2.5.6 of this RTC document, respectively. Discussion of comments that relate to electrification but not to the abovementioned technology issues, such as electrified vehicle penetration rates and similar aspects of the Proposed Determination, may be found in Chapters 2.1 and 2.3 of this RTC document.

Chapters 2.2.4.4.4 and 2.3.4.4.5 of the TSD review the state of technology for plug-in vehicles (PEVs), which include plug-in hybrid electric vehicles (PHEVs) and battery electric vehicles (BEVs). Chapters 2.3.4.3.4 and 2.3.4.3.5 of the TSD summarize the cost and effectiveness assumptions for these technologies and also include discussion of many of the related public comments on the Draft TAR, and EPA responses to those comments.

2.5.10.1 Plug-in Hybrid Electric Vehicles (PHEVs)

Summary of Comments on the Draft TAR addressed in the Proposed Determination

Few public comments on the Draft TAR concerned PHEVs specifically, as distinguished from broader issues common to plug-in vehicles in general. Some comments that were peripherally related to PHEVs were received in the context of credits, incentives, and flexibilities, which are discussed in Chapter 3.9 of this RTC document. Discussion of comments that relate to other aspects of electrification such as electrified vehicle penetration rates and similar aspects of the Proposed Determination may be found in Chapters 2.1 and 2.3 of this RTC document.

One comment was received relating to emissions on cap removal from the pressurized fuel tank that is commonly associated with PHEVs. EPA responded that, while it is well understood that the dual-powertrain aspect of PHEVs can present challenges for control of cold-start, evaporative, and cap removal emissions, such emissions are not directly within the scope of the Midterm Evaluation and are more properly addressed in the scope of other emission control programs that relate to evaporative emissions (see TSD Chapter 2.3.4.3.4). Additional responses to Draft TAR comments relating to criteria pollutants and evaporative emissions were presented in TSD Chapter 2.3.3.3.8 at p. 2-269 (see also Chapter 2.6 of this RTC document for a review of comments on this topic).

Summary and Response to Comments on the Proposed Determination

Comments on the Proposed Determination did not raise new issues related to PHEVs specifically. Comments from MECA repeated their comment on the Draft TAR, stating that “an increase in PHEV sales … may lead to an unintended increase in the VOC inventory” due to puff losses from pressurized fuel tanks. This comment relates more closely to the topic of evaporative emissions and criteria pollutants, which is discussed in Chapter 2.6 of this RTC document.

2.5.10.2 Battery Electric Vehicles (BEVs)

A number of public comments on the Draft TAR concerned battery electric vehicles. The comments described in this section relate specifically to battery electric vehicles as a GHG-reducing technology, rather than to the battery or non-battery technologies these vehicles may include. Comments related to the latter topics are described in detail in Chapters 2.5.5 and 2.5.6 of this RTC document. Discussion of comments that relate to other aspects of electrification such as electrified vehicle penetration rates and similar aspects of the Proposed Determination may be found in Chapters 2.1 and 2.3 of this RTC document.

<u>Summary of Comments on the Draft TAR addressed in the Proposed Determination</u>

Comments related to BEVs were focused on several aspects of BEV modeling, including driving range, projected fleet penetrations, aspects of cost such as overall cost as well as learning and warranty rates assigned to BEVs, accounting for upstream emissions in compliance projections, and power and acceleration levels.

One OEM commenter suggested that the 200-mile range of BEV200, the longest-range BEV in the analysis, may not be sufficient to compete with conventional vehicles on driving range over the long term, and that a longer range should be considered, which would increase projected costs. EPA acknowledged in the Draft TAR and in its response that despite the fact that some BEVs in today's market offer a range in excess of 200 miles, other near-term product announcements continue to target an approximate 200-mile range, making it uncertain at best that BEV200 will be as unrepresentative of future BEVs as the commenter suggests, or that BEV200 will fail to compete adequately with conventional vehicles to achieve the modest penetration rates projected in the Draft TAR analysis (see TSD Chapter 2.2.4.4.5 at p. 2-101 and Chapter 2.3.4.3.5 at p. 2-344). In estimating the number of ZEV program vehicles to include in the OMEGA analysis fleet, EPA also noted that it believes that the sales-weighted average approach that was used is the most appropriate and fair way to make this estimation with publicly available information, and this method would include the effect of longer-range vehicles that are present in the fleet (see TSD Chapter 2.3.4.3.5 at p. 2-344).

Other commenters suggested that BEV penetration rates projected in the Draft TAR analysis were too low. In some cases, this conclusion reflected the commenters' assertion that the projected effectiveness of advanced gasoline technologies was overly optimistic (an assertion with which EPA disagreed, and continues not to accept, see e.g. Section II.B of the Proposed Determination document at p. 24, among other places). In contrast, other commenters posited greater penetration rates on the expectation that BEV market share would grow rapidly for other reasons, such as better cost-effectiveness than assumed, or the groundbreaking effect of near-term product introductions, or better performance and convenience relative to conventional vehicles. EPA noted that the projected BEV penetrations of the Draft TAR are not directly chosen or selected, but rather result from the combined influence of many quantitative variables representing cost and effectiveness of these technologies as well as others that compete with them for inclusion in the projected compliant fleet. Similarly, market penetration that may result from other influences beyond cost effectiveness, such as relative utility, brand appeal, performance, or other factors are less tangible and quantifiable by their nature and present difficulties with their representation in a model that is driven primarily by cost effectiveness. More discussion may be found in TSD Chapter 2.3.4.3.5 at p. 2-343 to 2-344.

With respect to comments expressed by a BEV manufacturer and others that overall BEV costs and warranty cost reserves may be overstated, EPA noted that manufacturers that are dedicated expressly to BEVs may experience different learning effects and cost structures than other manufacturers, and that an accurate accounting of electrification costs during the time frame of the rule should represent costs as they are likely to be experienced across the full spectrum of manufacturers, even those that may utilize BEVs as a relatively small portion of their compliance path. This is consistent with the relatively modest levels of BEV penetration that the Draft TAR analysis projected, and the observation that significant uncertainty remains as to warranty reserves or other aspects of indirect cost that will be representative of the industry as a whole as it evolves. While EPA generally agreed that BEV costs appear to be continuing on a downward trajectory, quantifying that trajectory in a manner sufficient to inform the applicability of the non-battery cost estimates would require more detailed information than the comments provide, such as detailed cost breakdowns and the assumptions that underlie them. EPA believes that its current non-battery cost estimates continue to represent a reasonably conservative assessment within the context of the modeling as a whole. For complete discussion of these comments and responses, see TSD Chapters 2.3.4.3.5 at p. 2-343, TSD 2.3.4.3.6 at p. 2-346 to 2-348, and TSD 2.3.4.3.7 at p. 2-357.

EPA also received some comments on the assumed production volumes for electrified vehicles as being higher than anticipated by penetration levels projected in the Draft TAR. EPA addressed comments related to the effect of assumed volumes for battery production in TSD Chapter 2.3.4.3.7.4 at p. 2-387 to 2-388, where the rationale for the chosen volume is clarified and expanded (see also Chapter 2.5.5 of this RTC document). With respect to assumed BEV production volumes and penetration projections, much of the same rationale applies, as was discussed in more detail in TSD Chapter 2.3.4.3.6 at p. 2-347 to 2-348.

In response to Draft TAR comments on the effect of phasing in of accounting for upstream emissions of BEVs and PHEVs in the compliance analysis, for the Proposed Determination analysis, EPA included upstream emissions for BEV operation and the electricity portion of PHEV operation in the compliance determinations for all manufacturers by MY2025 (TSD Chapter 2.3.4.3.5 at p. 2-344).

One Draft TAR commenter stated that the power levels assumed for plug-in vehicles (both PHEVs and BEVs) were lower than that manufacturer typically provides in its vehicle line. EPA responded to this comment in TSD Chapter 2.3.4.3.7 at p. 2-358, in part by acknowledging that although different manufacturers may have differing targets for performance, this is also true for many other vehicle attributes, and while it would be difficult to extend the analysis to represent a specific manufacturer's performance levels, variations in vehicle performance are now modeled more effectively in aggregate due to modifications in the vehicle classifications. EPA also described its method for assigning motor sizing and 0-60 acceleration times for plug-in vehicles in TSD Chapter 2.2.4.4.6, and its outlook on future trends in 0-60 acceleration times in TSD Chapter 2.3.4.3.7.4 at p. 2-359.

Comments were also received on the subject of incentives for BEVs, including the incentive multiplier for MYs 2017 through 2021, and the 0 g/mi accounting for tailpipe emissions for MYs 2017-2025 (subject to sales thresholds for MYs 2022-2025). Public comments received on these incentives and multipliers were addressed in Section B.3.4.2 of the Proposed Determination Appendix, and are reviewed again in Chapter 3.9 of this RTC document.

Summary and Response to Comments on the Proposed Determination

Several comments on the Proposed Determination related to BEVs. Some of these comments repeated points raised previously in comments on the Draft TAR and addressed by EPA in the Proposed Determination, as summarized above.

Comments from Faraday Future were strongly in favor of the Proposed Determination, and presented a number of arguments regarding the potential for rapidly growing BEV market penetration independent of regulatory action, due in part to falling costs, consumer acceptance, and other influences. The comments also argued that this projected increased penetration of BEVs could justify amending the standards to make them more stringent. These comments largely repeated the comments on the Draft TAR and cited several references that EPA had incorporated into the Proposed Determination. EPA addressed these comments in the Proposed Determination and TSD, as described above.

ICCT repeated its contention that EPA may be overestimating BEV costs, and this concern was also raised in comments from UCS. EPA addressed this and similar comments which had been submitted on the Draft TAR in TSD Chapter 2.3.4.3.6 at p. 2-346 to 2-347. UCS also noted that any overestimation of BEV costs would probably not have a significant impact on projected compliance costs for the time frame of the 2017-2025 rule, but felt it necessary to flag the issue on the basis that overestimating BEV costs could have a greater impact on development of future rulemakings. EPA agrees, and anticipates continuing to refine the characterization of BEV costs as appropriate to the consideration of potential light-duty rulemakings applicable to the post-2025 time frame.

2.5.11 Fuels / Octane

Summary of Comments on the Draft TAR addressed in the Proposed Determination

Chapter 2.3.1.3 of the TSD discussed the new Tier 3 fuel and the properties of this fuel, including aromatics, ethanol, and octane. The TSD discussion considered comments received on the Draft TAR on this topic, and contains the EPA response to those comments. Further discussion of the impact of Tier 3 fuel specific to engine technologies can be found in Chapters 2.3.4.1.8 and 2.3.4.1.9 of the TSD, as well as Appendix D to that document.

Comments received on the Draft TAR claimed that EPA’s assessment of certain engine technologies that are sensitive to fuel octane did not account for the lower octane of Tier 3 fuel and the anticipated resulting degradation in efficiency. EPA’s response in the Proposed Determination TSD Chapter 2.3.1.3 described the test fuel properties for both Tier 2 and Tier 3 fuels before discussing the interaction of octane with both test cycles and real world driving. The response explains that the assessment of technology effectiveness was not premised on a requirement for high octane fuel for normal operation. In fact, two key engine technologies tested for our analysis in support of the GHG standards, downsized turbocharged engines (including Ford Ecoboost engines with up to 24-bar BMEP) and non-hybrid Atkinson cycle engines, are currently produced by several manufacturers without a high octane fuel usage recommendation from any manufacturer when operating under normal conditions. Current EPA guidance provides an assurance at certification that vehicles not labeled as requiring premium are not octane sensitive under normal operating conditions, including all EPA test cycles. Additionally, EPA's response in Chapters 2.3.4.1.8 and 2.3.4.1.9 of the TSD, as well as the discussion summarized in Table 4.2 (in TSD Appendix D), provided test results supporting the determination that two main engine technologies (turbocharged/downsized and Atkinson) show a small reduction in CO_2 when using Tier 3 regular grade octane E10 fuel.

Summary and Response to Comments on the Proposed Determination

In comments on the Proposed Determination, the Alliance commented that as of MY2020, all testing for GHG compliance is required to use gasoline blended with ethanol, but that EPA's modeling in the Proposed Determination, which applies to the full time frame of the rule, reflects non-blended fuel. The Alliance suggests that EPA's response that the difference is not consequential here to be incongruous with its continued modeling practice, and recommends that all modeling should use the fuel mandated for the regulatory time period being evaluated.

EPA's response in Chapters 2.3.4.1.8 and 2.3.4.1.9 of the TSD, as well as the discussion summarized in Table 4.2 (in TSD Appendix D), provided test results supporting the determination that two main engine technologies (downsized turbocharged and Atkinson) as well as several other engine technologies show a small reduction and not a penalizing increase in CO_2 when using Tier 3 regular grade octane E10 fuel. This is because the change to the Tier 3 E10 fuels included a substantial reduction in aromatics resulting in lower carbon content of the fuel and therefore producing lower CO_2 emissions even in cases with an increase in fuel consumption. Based on these test results, EPA concluded that modeling performed using the Tier 2 high octane E0 fuel did not provide a GHG advantage over the Tier 3 regular grade octane E10 and that the Alliance concern that all modeling should use the E10 fuel required after MY2020 does not result in an increase in GHG stringency when manufacturers start using the E10 test fuel in MY2020.

Several ethanol industry trade groups commented that the higher octane fuel represented by mid-level ethanol fuel blends (20 to 40 percent ethanol) can improve engine efficiency and may even be necessary to meet the stringent GHG emission standards. Specifically, they commented that higher octane fuel would enable higher compression ratio engines which typically result in engine efficiency improvements. Further, these organizations commented that EPA did not consider fuels and vehicles together in our projection of potential technology paths for compliance with the standards.

EPA appreciates the comments from the ethanol trade organizations regarding the potential for engine efficiency improvements from high octane fuels. EPA disagrees with the conclusion that high octane fuel is necessary to obtain the engine efficiency levels necessary to meet the standards. This is evident in the agency's analysis of two primary engine technology options that could be used to meet the standards: Atkinson cycle engines and turbocharged downsized (TDS) engines. EPA's response in Chapters 2.3.4.1.8 and 2.3.4.1.9 of the TSD, as well as the discussion summarized in Table 4.2 (in TSD Appendix D), provided test results supporting the conclusion that TDS and Atkinson technologies do not require premium fuel to achieve the standards. This is largely because both of these technologies if properly implemented are able to optimize engine efficiency over a varied range of operation by either adjusting the effective compression ratio in the case of the Atkinson engines or by adjusting the amount of cylinder charge in the case of turbocharged downsized engines, particularly as it applies to real world and test cycle operational constraints.

EPA does not disagree that high octane fuel may provide some additional performance improvements beyond what is required to meet the standards, such as increased engine performance levels when operating on high octane, as explained in some manufacturers' owner's manuals (EPA discussed this and related points in TSD Chapter 2.3.1.3 at p. 2-211). High octane fuel may also help address some shortfalls in FE and GHG emissions in real world situations where some technologies may be particularly sensitive, such as high load under towing conditions or high ambient temperature operation in summer seasons. Under these and other extreme conditions, some manufacturers are already recommending use of premium high octane fuel in currently produced vehicles. Note that EPA does not preclude vehicle manufacturers from using a high octane fuel for certification of GHG emissions if they properly label vehicles as "premium required." In addition, premium gasoline is widely available in the US market. The Tier 3 certification fuels include a high octane E10 fuel for "premium required." in addition to a high octane E85 fuel for flex fuel or dedicated alternative fuel vehicles. Manufacturers also have a pathway to certify a vehicle using a mid-grade ethanol fuel (presumably with high octane properties) if they determine this to be a pathway for compliance with GHG emission standards. As discussed in the TSD Chapter 2.2.2.14 at p. 2-44, EPA looks forward to reviewing the results of the Department of Energy research project "Co-Optima" for potential future options for engines and fuels, including results from high octane mid-level ethanol fuel blends.

Several comments from the ethanol trade organizations highlighted the issue of updating the R-factor term used in fuel economy calculations, on the basis that the underlying data used to determine this adjustment was based on outdated 1975 test fuel. As discussed in TSD Chapter 2.3.1.3, consistent with its historical practice, when test fuel properties are updated EPA determines appropriate test procedure adjustments, which include potential updates to R-factor, in order to maintain the same level of stringency of the GHG and fuel economy standards between the Tier 2 E0 and Tier 3 E10 fuels. This work is currently under regulatory development in consultation with vehicle manufacturers, industry and other stakeholders.

2.5.12 Mass Reduction

Summary of Comments on the Draft TAR addressed in the Proposed Determination

The analysis performed for the 2012 FRM assumed that all vehicles in the baseline start with the same opportunity for mass reduction. For the Draft TAR analysis, EPA revised this assumption by characterizing differences in the incremental cost and feasibility of additional mass reduction between vehicles in the baseline. We received comments on the Draft TAR which, while generally supportive of the direction of the change, expressed concern that we had not properly accounted for the amount of mass reduction already implemented in the baseline fleet. One specific example provided by the commenters involved the value of 200 lbs. assumed in the Draft TAR to account for the mass of AWD/4WD systems. EPA maintained this assumption for the Proposed Determination, noting in Chapter 2.3.4.6 of the TSD that the vehicles examined are typical of the AWD/4WD vehicles within the fast-growing crossover utility segment, and that while this weight may under-represent some of the largest 4WD vehicles, it may also over-represent some of the smallest AWD vehicles.

FCA commented that the effectiveness estimates made by EPA for mass reduction were not accurate due to the lack of consideration of Equivalent Test Weight (ETW) class bins and their effect on fuel economy testing. That is, the test method used for fuel economy certification uses a nominal ETW value rather than the precise actual weight of the vehicle. FCA recommended that

EPA adjust its modeling so that mass reduction benefits are only reflected via the resulting change to ETW class bin. As discussed in Chapter 2.3.4.6 of the TSD, EPA did not agree with this recommendation. The average mass reduction projected in the Proposed Determination is approximately 9 percent, which would move many vehicles in the fleet down by one or two ETW bins. EPA stated its belief that the approach of allowing mass reduction in continuous increments (actually 0.5 percent increments in the OMEGA analysis) does not cause a systemic underestimation of costs, because cases where manufacturers may be getting less benefit from mass reduction than projected in our analysis would be offset by other cases where manufacturers may be getting more benefit.

Summary and Response to Comments on the Proposed Determination

The Alliance reiterated (the Alliance comments, p. 31) that OMEGA modeling for mass reduction is inconsistent with the mandated test method and is therefore improper. Specifically, the issue raised previously by the Alliance and FCA in comments to the Draft TAR that the regulation assigns discrete bins whereas the OMEGA modeling uses a continuous function. The Alliance also finds EPA's explanation that the modeling does not result in systematic over- or under-estimation of costs to be without support. In response, EPA disagrees that the use of a continuous function rather than discrete binning necessarily results in significant distortion of costs. First, a portion of the effectiveness benefit of mass reduction is due to the influence of vehicle mass on coast down coefficients, and this benefit is accounted for in EPA's analysis method consistent with the certification process regardless of whether discrete or continuous test bins are used. Second, EPA maintains the position presented in the Proposed Determination regarding the use of continuous as opposed to discrete bins – the continuous method is a simplified approach that, although not structurally identical to a binned approach, is likely to generate a positive error for some individual vehicles and a negative error for others, which on average across the fleet would be expected to cancel each other out, resulting in no systematic net error in the aggregated result.

In contrast, ICCT commented that EPA "systematically underestimates" mass reduction potential in the fleet, and provides 15 examples of models that have reduced mass by 4 to 15 percent, citing many co-benefits to consumers. UCS also characterized the projected levels of mass reduction as conservative. EPA agrees with the ICCT comment that a number of vehicle models in the Proposed Determination analysis have achieved more mass reduction than the 9 percent average penetration projected, but this does not necessarily indicate that potential for mass reduction to contribute to compliance pathways has been systematically underestimated, or is overly conservative as suggested by UCS. Although EPA believes that it is feasible for many vehicles to achieve up to 20 percent mass reduction, the projection of only 9 percent average mass reduction in the cost minimizing compliance pathway indicates that when this technology competes with the full array of other available GHG reducing technologies, few vehicles are projected to apply the maximum level of 20 percent.

Global Automakers commented on the increase in average projected mass reduction from 7 percent to 9 percent. Global stated that this was a significant change in mass reduction and evidence of a wide variation in EPA's results. Regarding the Global Automakers comment, EPA noted in the Proposed Determination Table IV.5 and TSD Appendix C.1.1.3.1 at p. A-132 that the reference point for presenting mass reduction technology penetration values was revised from using the baseline value (as in the Draft TAR) to using the null technology package. The increase from 7 to 9 percent is therefore primarily the result of reporting the estimated mass reduction already present in the baseline. The 2 percent difference simply reflects differences in how mass reduction in the baseline is presented in the technology penetration tables between the Draft TAR and the Proposed Determination.

Honda provided a post-Draft TAR presentation to EPA in November, 2016. While the presentation was not in response to the Proposed Determination, Honda provided a redacted version of the presentation to the Docket when submitting its public comment (which directed EPA to the comments from Global Automakers for which Honda indicated support). In the presentation material, Honda indicates that EPA underestimates the amount of mass reduction already contained in the Honda baseline fleet, and that the resultant projected cost of compliance for Honda is therefore not correct. EPA has considered this information but does not agree that the incremental costs for additional mass reduction beyond what exists in the Honda baseline vehicles have been underestimated, nor does EPA agree that the feasibility of additional mass reduction has been overestimated. Honda is correct in its interpretation of how the baseline mass reduction was established; however, they do not consider that the curves used to calculate the cost of mass reduction were directly informed by the detailed engineering study based on a teardown analysis a 2011 Honda Accord. To the extent that the Accord already incorporated lightweighting materials and a mass-efficient design in MY2011, then the resulting cost curve, based on reducing the mass of the Honda Accord, would reflect higher costs.

FCA provided several comments relating to mass reduction in general and the levels of mass reduction EPA projected for its fleet, as support for their contention that the technology pathways projected for FCA are unrealistic.

The FCA commenter noted that, between the Draft TAR and Proposed Determination, the projected percent mass reduction for FCA's fleet increased from 5.9 percent to 11.6 percent, and stated that this level of mass reduction would "require complete product redesigns in less than eight years." With regard to the increase in projected mass reduction, EPA addresses a similar comment with respect to the mass reduction projections for Mercedes-Benz in Chapter 2.8 of this RTC document. That response also applies to the FCA projections. In addition, the response to the Global Automakers comment on the increase in average projected mass reduction from 7 percent to 9 percent, provided earlier in this chapter, should also be considered when comparing mass reduction projections between the Draft TAR and Proposed Determination.

With regard to the need for complete redesigns, EPA notes (in addition to the responses above, which also carry implications for the interpretation of the new projections) that the mass reduction projections are only part of one potential compliance pathway. As discussed in Appendix C of the Proposed Determination at p. A-144, EPA performed a sensitivity analysis in which no additional mass reduction is applied beyond that included in the projected baseline fleet. As discussed at p. A-146 of that document, this analysis showed that on the fleet level, the incremental cost per vehicle result is not heavily dependent on mass reduction, and that cost-effective compliance pathways continue to exist.

FCA stated that "even small percentage weight reduction targets are challenging for automakers to realize given the offsetting customer demand for additional content/features and regulatory safety requirements." In response, EPA has acknowledged that content and safety requirements can compete with fuel economy for the benefits of mass reduction, and that in the past manufacturers have used mass reduction to offset the effect of added features or safety measures. For example, see the TSD at p. 2-146 and p. 2-156. Consistent with the approach used by EPA for other technologies to estimate technology costs and effectiveness while holding vehicle utility and performance constant, EPA has also made it clear that the cost curves used in its analysis are entirely applied towards a reduction in vehicle curb weight, as opposed to offsetting mass increases from the addition of content and features. See Draft TAR at p. 5-368. EPA has also acknowledged that other regulatory requirements may add weight, and in composing the baseline for the Draft TAR, accounted for new finalized safety regulations that were deemed to have an impact on mass (as discussed for example in Chapter 5.3.4.6.2 of the Draft TAR). Given the conclusion of the mass reduction sensitivity discussed above, EPA believes that accounting for the effect of future safety requirements would be unlikely to change the conclusions of our analysis.

FCA also stated, "It is generally accepted that … relative to cost, the percent mass reduction exhibits linear behavior up to 10% and beyond 10% exhibits *exponential* behavior," and cites a September 2016 study by the Center for Automotive Research as support. EPA notes that the commenter does not specify whether the cost reference is to cost per unit mass removed, or to total cost, making it difficult to evaluate this comment because the cost unit affects the form of the curve. But in general terms, the cost curves EPA uses in its analysis (see Draft TAR Figures 5.126 and 5.127 at p. 5-380 for examples) are consistent with the general cost curve presented in a previous study by the same author of the cited study, which was reproduced in the Draft TAR as Figure 5.116 at p. 5-368. They generally show increasing costs for increasing percentages of mass reduction, ranging from a cost savings at lower levels of mass reduction, transitioning to increasingly higher costs at increasing levels of mass reduction. EPA does not find clear support in the cited study for the statement that industry and academia generally accept that the cost of mass reduction transitions from linear to exponential at 10 percent. Rather, the commenter may be suggesting that a certain degree of mass reduction is achievable at a reasonable cost, but that the fleet average level projected for FCA lies beyond an exponential transition and therefore is unreasonable. EPA does not find this argument persuasive. The EPA cost curves exhibit the expected behavior of assigning increasing rates of cost to increasing levels of mass reduction. The form, shape, and magnitude of these curves were established by means of rigorous and detailed empirical studies as described in Chapter 5.3.4.6 of the Draft TAR.

American Iron and Steel Institute (AISI) stated that EPA had not addressed its Draft TAR comments on the cost of insurance and repairs for lightweighted vehicles and on the impact of lightweighting on business models and infrastructure. In their Draft TAR comments, AISI stated that collision repair costs "will have an impact on the yearly vehicle insurance costs, with an initial cost estimate of $396 in 2010 dollars" and attributed that to the Draft TAR. However, AISI misunderstood that $396 value which was instead an estimate of the average value of collision insurance, not an estimate of incremental cost increases resulting from the standards. Importantly, EPA does consider the increased cost of insurance in the payback analysis—increased costs meant to address the possible increase in collision-related repairs on the higher cost vehicles under the standards. As described in Chapter 3.11.2 of the TSD (at p. 3-53), EPA considered the impact of the standards on auto insurance expense by considering the cost of insurance as being proportional to new vehicle price. To the extent that vehicles that incorporate advanced technologies experience an increase in average vehicle price, projected insurance costs are increased in proportion. Similarly, as described in TSD Chapter 2.3.2.3.2 at p. 2-230, EPA's analysis accounts for the costs of repairs covered by manufacturers' warranties. The indirect cost multipliers (ICMs) applied in EPA's analyses include a component representing manufacturers' warranty costs. Also as described in that section, sufficient information is not available to quantify the frequency and cost of different types of repairs. The projected cost of mass reduction technology does not include a factor to represent potential differences in repair costs of various materials, in part because there is little data available to reliably characterize the existence or magnitude of repair cost differences for each specific material that might be applied in the future. It not clear that the implementation of lightweight materials will necessarily result in higher repair costs, and simply drawing a conclusion on the direction any impact of a materials change on future overall repair costs may be unwarranted. For example, in the particular case of the vehicle body, repairing a panel made from aluminum will involve different (and possibly costlier) techniques than are used for a steel panel, but the necessity for repair may be reduced due to improved corrosion and dent resistance. Furthermore, the future cost of repairs is difficult to predict in part because, as new materials gain increased usage in the fleet, repair facilities and expertise will have to gain experience and capacity for performing the repairs, a process which is likely to impose higher costs in the short term but which will gradually fall over time.

The AISI comments on the impact of lightweighting on business models and infrastructure appear to relate primarily to a concern that automakers should remain free to choose materials that appropriately support the full spectrum of considerations relevant to their business model, and not be directed towards higher-cost materials that may have unintended environmental and other consequences. The implication is that the assessment of potential lightweighting materials that EPA presented in the Draft TAR and Proposed Determination may act as guidance to automakers as to which materials to use, and that if the assessment is not accurate as to relative material costs and capabilities, automakers may fail to select the most appropriate materials. However, the EPA assessment is not intended as prescriptive guidance to manufacturers regarding which particular materials to use, and it seems unlikely that a manufacturer would simply defer to the conclusions of the assessment without considering the specific needs and goals of its business model and market segment. AISI also suggests that the assessment is biased toward replacing steel with lower-density materials such as aluminum and other materials. The cost curves that EPA uses to estimate the cost of lightweighting are derived from assessments of the costs of achieving various levels of mass reduction by means of various types of materials, including steel, aluminum, and other materials. EPA's projected cost-minimizing compliance pathway includes varying levels of penetration of mass reduction technology for different vehicles. The assessments that form the basis of the cost curves suggest that steel is likely to play a strong role in achieving target mass reductions at the lower end of the curve, while lower density materials are likely to play a strong role in achieving target mass reductions at the higher end of the curve. In the Draft TAR, EPA extensively cited examples of successful applications of advanced high strength steels, which clearly demonstrate the capabilities and potential cost-effectiveness of this family of materials. In all of the technology assessments performed for the light-duty GHG standards, EPA has assessed technologies on a performance basis, and accordingly, with respect to mass reduction technologies, does not recommend one family of materials over any other.

AISI also requested a response to its comment suggestion that EPA provide off-cycle credits based on the GHG impact of the use of lightweight materials. This comment relates more specifically to off-cycle credits. Comments relating to off-cycle credits are addressed in Chapter 3.9 of this RTC document.

An anonymous citizen commented that the drive to reduce mass to improve fuel economy has caused manufacturers to eliminate the full size spare tire (as an alternative to applying mass reduction technology) and suggested that the fuel economy benefit would not be realized if the owner chooses to add a full size spare. EPA recognizes that many manufacturers have replaced the full size spare with a smaller temporary spare, and in some cases have even replaced the temporary spare with a tire repair kit, which includes tire sealant and an inflator. While this does reduce vehicle mass, it is not clear that fuel economy regulations are the only driver of this trend. Removing the spare reduces manufacturing cost, and also frees up interior space, which can help with component packaging and improve cargo capacity. Some vehicles without a spare are equipped with so-called run-flat tires, which are designed to maintain enough pressure after being punctured that the car may be driven to a service location for tire repair instead of relying on a spare. While removing the spare may therefore provide a limited opportunity to improve fuel economy, these other factors are also likely to be contributing to this trend.

2.5.13 Aerodynamics

Summary of Comments on the Draft TAR addressed in the Proposed Determination

For the FRM and Draft TAR technical assessments, EPA assumed constant cost and feasibility assumptions for incremental improvements in aerodynamic performance for every vehicle within a class. Several stakeholders submitted comments that EPA's Draft TAR assessment did not account for the drag reduction that some vehicles have already adopted, and recommended that the aero levels in the baseline fleet reflect appropriate drag reduction achieved by each vehicle. Because these comments were made in reference to technologies represented in the baseline fleet, they are also reviewed in Chapter 2.7.1 of this RTC document.

EPA agreed with the commenters that it is appropriate to account for aerodynamic drag reductions already present in the baseline fleet in order to avoid overestimating the amount of additional improvement that can be achieved at a given cost. In response to these comments, for the Proposed Determination, EPA largely accepted commenters' suggestions to account for aerodynamic improvements already present in the baseline fleet, using MY2015 certification data for purposes of that accounting. EPA used an analysis of coastdown coefficients to estimate the levels of aerodynamic drag reduction already present in MY2015 vehicles. The vehicles were then binned into one of three aerodynamic technology levels according to the potential for future improvement. The three levels correspond to the two aerodynamic technology levels modeled throughout the EPA analysis (Aero1 and Aero2), and a zero-technology level representing no technology added. The assignment of each baseline vehicle to one of three aerodynamic technology levels (rather than specific drag coefficient or frontal area values) is therefore consistent with the structure of the modeling. The Aero1 and Aero2 levels and the accounting for drag reducing technology in the baseline fleet were described in Chapter 2.3.4.4 of the TSD and is also reviewed in Section A.2.1 of the Proposed Determination Appendix at p. A-2 and A-3.

Summary and Response to Comments on the Proposed Determination

Mercedes-Benz expressed appreciation for the changes made to the 2015 baseline fleet between the Draft TAR and the Proposed Determination to more accurately reflect the baseline level of aerodynamic technology already present the fleet. EPA notes that these changes were made as a result of the public comments on the Draft TAR, and reflected the suggestions in those comments (as well as reflecting EPA's announced intention to use final MY2015 certification data in the analysis as it became available). With respect to accounting for aerodynamic improvements, for the Proposed Determination, EPA agreed with Draft TAR commenters that the approach in the Draft TAR, whereby every vehicle in the baseline fleet had the potential for 20 percent improvement in aerodynamic drag, failed to account for improvements already made in certain baseline vehicles, and thus overstated potential feasible improvements. In estimating the amount of aerodynamic drag already present in the 2015 baseline fleet, EPA largely accepted commenters' suggestions to account for aerodynamic improvement already achieved for each vehicle in the 2015 fleet, using 2015 certification data for purposes of that calculation. See TSD Table 2.139 showing aerodynamic drag area statistics for each of the 17 size classes of vehicle.

In comments that were raised in the context of OMEGA outputs, Toyota stated that in the Proposed Determination, EPA did not account for the additional weight of the Aero2 package for the Tundra/Tacoma platform. This comment referred back to a Toyota comment on the Draft TAR that Toyota felt EPA had only partially addressed, which was, "OMEGA shows that many vehicles, such as the Tundra and Tacoma, will have both AERO2 and a net weight reduction. Although it is possible to use AERO2 on these trucks, the expectation is that the weight of the vehicle would increase, not decrease as shown by OMEGA. This is because the additional components associated with AERO2 performance improvements will increase the weight of the vehicle."

For technologies that can ordinarily be expected to add significant weight to the vehicle, EPA does account for the additional weight and its impact on the ability to achieve a net weight reduction by application of mass reduction technology. For example, as described in Section 2.3.4.3.7.1 of the TSD, the weight of batteries and other components of electrified vehicles is explicitly modeled and accounted for because it is clear that their weight is significant and may or may not allow a net vehicle weight reduction to be achieved within the limit of allowable application of mass reduction technology. In fact, for these vehicles, OMEGA tracks both a percent net weight reduction achieved (WR_{net}) and a percent of mass reduction technology applied (WR_{tech}). In many cases, WR_{tech} is greater than WR_{net}, indicating that the weight of the added battery and electric drivetrain (after conventional powertrain components are removed) resulted in less net weight reduction than the applied level of mass reduction technology otherwise would have achieved. In some extreme cases, there is a net weight increase, indicating that the added mass was so great that it precluded achieving any net weight reduction within the limits on allowable application of mass reduction technology. In the case of other technologies (such as Aero2), the added weight is relatively much smaller and would not be expected to preclude the possibility of achieving any net weight reduction on the vehicle. Toyota did not specify in its comments on either the Draft TAR or Proposed Determination the magnitude of the weight increase that it expects Aero2 to add to a Tundra-type vehicle, nor provided details as to why it expects the weight increase to be so significant that it would preclude the possibility of achieving any net weight reduction on a vehicle of this type (as OMEGA showed). In any case, the relatively small mass addition that is likely to be associated with Aero2 is unlikely to significantly impact the ability to combine Aero2 with mass reduction technology and thereby achieve a net weight reduction of the vehicle similar to what the OMEGA output indicated.

An anonymous citizen expressed concern over reductions in vehicle interior volume. While this comment may refer to general downsizing of vehicles for fuel economy, it may also refer to the potential for a manufacturer to reduce aerodynamic losses by reducing the frontal cross sectional area of the vehicle rather than or in addition to improving its coefficient of drag. EPA has not observed a discernible trend toward reduction of frontal area, as most manufacturers wish to maintain the utility of interior volume and have focused on reducing drag coefficient by means of modifications to the exterior surface and shape of the vehicle. EPA expects that manufacturers will continue to improve the efficiency of their designs to be able to maintain interior volume while reducing aerodynamic drag. This can be accomplished in part by making more efficient use of available space within the envelope of the vehicle. For example, in the discussion of aerodynamics in the Proposed Determination we cited the redesign of the 2015 Acura TLX sedan as having reduced frontal area by 1.5 percent without sacrificing interior space (see TSD Chapter 2.2.5.2 at p. 2-137) due to the design approach described in the cited presentation materials from Acura. It should also be noted that the footprint-based standards that are the subject of this Final Determination are designed to improve the fuel economy of vehicle of all sizes, without compelling manufacturers to manufacture smaller vehicles in order to comply with the standards.

2.5.14 Tire Rolling Resistance

Summary of Comments on the Draft TAR addressed in the Proposed Determination

For the FRM and Draft TAR technical assessments, EPA assumed constant cost and feasibility assumptions for incremental improvements in tire rolling resistance. Commenters on the Draft TAR noted that "low rolling resistance tires are increasingly specified by OEMs in new vehicles," yet were not accounted for in EPA’s baseline fleet. Because these comments were made in reference to technologies represented in the baseline fleet, they are also reviewed in Chapter 2.7.1 of this RTC document.

EPA agreed with the Draft TAR commenters that it is appropriate to account for tire rolling resistance reductions already present in the baseline fleet in order to avoid overestimating the amount of additional improvement that can be achieved at a given cost across the fleet. In response to these comments, for the Proposed Determination, EPA largely accepted commenters’ suggestions to account for rolling resistance improvement already present in the baseline fleet, using MY2015 certification data for purposes of that accounting. EPA used an analysis of coastdown coefficients to estimate the levels of tire rolling resistance reduction already present in MY2015 vehicles, and assigned one of three tire rolling resistance levels to each vehicle in the baseline fleet. The three levels correspond to the two tire rolling resistance technology levels modeled throughout the EPA analysis (LRRT1 and LRRT2), and a zero-technology level representing no technology added. The assignment of each baseline vehicle to one of three rolling resistance levels (rather than a specific rolling resistance value) is therefore consistent with the structure of the modeling analysis, and while it is not intended to exactly represent the specific level of technology present in any specific individual vehicle, EPA believes that it is effective at representing existing technology and remaining potential in aggregate across the fleet as required for the purposes of the analysis. The LRRT1 and LRRT2 levels and the accounting for rolling resistance technology in the baseline fleet were described in Chapter 2.3.4.5 of the

TSD at p. 2-410 and is also reviewed in Section A.2.1 of the Proposed Determination Appendix at p. A-2 and A-3.

Summary Comments and Responses on the Proposed Determination

Some OEMs, through confidential comments provided to EPA, questioned the feasibility of reducing tire rolling resistance. These comments included information describing the rolling resistance characteristics said to be present on specific vehicles or across their respective fleets to support their position that many vehicles in production already apply significant amounts of rolling resistance technology and that this places the potential for further reductions in doubt. In response, EPA has acknowledged that existing vehicles include varying levels of rolling resistance reduction and has attempted to account for this by assigning levels of existing rolling resistance technology to vehicles in the baseline fleet, as described above and in Chapter 2.3.4.5 of the TSD at p. 2-410. As stated previously in this discussion, EPA believes that on average and for the purposes of the overall analysis, this method is effective at representing the amount of technology already applied in aggregate across the fleet, and the remaining potential yet to be applied.

2.5.15 Low Drag Brakes

Summary of Comments on the Draft TAR addressed in the Proposed Determination

The state of low-drag brake technology was discussed in TSD Chapter 2.2.8.4. TSD Chapter 2.3.4.7.4 discussed cost and effectiveness assumptions and addressed public comments that were received on this technology.

In comments on the Draft TAR, Toyota commented on several aspects of EPA's low-drag brake assessment. With respect to the Draft TAR analysis, Toyota commented on the conclusions regarding the Direct Manufacturing Costs (DMC) and stated that in order to "calculate such a detailed cost, it must be fixed with a special brake system of that of a specific supplier." In response, EPA noted that the DMC for this technology is not derived from a specific supplier's design, but rather is an aggregate cost representing all of the changes that can be made to the brake system to reduce drag, including caliper seal and return rate and rotor and lining changes. This is a more reasonable basis for a cost estimate than a specific supplier quote because it represents individual component costs that should be present in any specific supplier or OEM design. Toyota also commented on EPA's summary of available zero drag brake systems. In response to these comments, EPA updated the description of the zero drag brake technology in TSD Chapter 2.2.8.4, while noting that zero-drag brakes were not included in the Draft TAR or Proposed Determination analyses. It should be noted that this makes the overall technology assessments more conservative, because this represents one more technology option that was not considered in the analysis but which manufacturers have at their option to comply with the standards.

Commenters on the Proposed Determination did not present additional comments on low drag brake technology.

2.5.16 Air Conditioning

2.5.16.1 A/C Efficiency Credits

This chapter reviews comments relating to A/C efficiency credit mechanisms. The A/C efficiency credit program includes several provisions for earning credits, including a pre-defined credit menu (i.e. the list of credits for air conditioning system efficiency in 40 CFR 86.1868-12 for which the regulation provides a default value), which manufacturers can access by completing testing requirements; an option for engineering analysis to replace part of the testing requirement; and an alternative pathway to credits through the off-cycle credit program.

Because of its overlap with the off-cycle program, comments relating to A/C efficiency are in some cases better addressed in the context of the off-cycle program. Comments on the off-cycle program are reviewed in Chapter 3.9 of this RTC document.

Summary of Comments on the Draft TAR addressed in the Proposed Determination

Chapter 2.2.9.1 of the TSD discussed the air conditioning (A/C) efficiency credit program and addressed comments on the Draft TAR that relate to this topic.

Some comments received on the Draft TAR concerned the process for applying for A/C credits under the off-cycle pathway. These comments primarily requested that EPA simplify and standardize the off-cycle application process, in the specific context of application for A/C efficiency credits. Commenters cited the need to provide greater certainty to manufacturers that credits would be approved before making investments, and to reduce application burden. EPA's response to requests for simplification and standardization of the off-cycle application process are found in Section B.3.4.1 of the Proposed Determination Appendix at p. A-103 to A-106.

Other comments noted the importance of continuing to incentivize further innovation in A/C efficiency technologies as new technologies emerge that are not in the credit menu, or when manufacturers begin to reach the regulatory caps on menu credits. These commenters suggested that EPA should consider adding new A/C efficiency technologies to the credit menu and/or update the credit values, particularly those that would otherwise qualify for credits through an off-cycle application as a non-menu A/C efficiency technology, or through a demonstration that credit beyond the menu default value is warranted. EPA acknowledged that the credit menu has been well received as a way to incentivize A/C improvements, but stated that it continues to believe that expanding the credit menu would be inconsistent with the goal of transitioning the A/C program toward a performance basis, and declined to alter the rule by expanding the list of default A/C efficiency technologies, or by changing the default values. Non-menu improvements would continue to be eligible for additional credit pending demonstration of performance and approval by the agency. The full discussion is found in TSD Chapter 2.2.9.1.1 at p. 2-189.

Several commenters questioned the applicability of a cap on non-menu A/C efficiency technologies claimed through the off-cycle process. EPA clarified that although the specific regulatory caps specified under 40 CFR 86.1868-12(b)(2) apply to menu-based A/C credits and are not part of the off-cycle regulation (which is defined at 40 CFR 86.1869-12), EPA has discretion through its authority in the off-cycle approval process to take into account factors deemed relevant, including consideration of synergies or interactions among applied technologies, which could potentially be addressed by application of some form of cap or other applicable limit on total A/C credits, if warranted. More discussion on this topic is found in TSD Chapter 2.2.9.1.1 at p. 2-190.

Some commenters expressed uncertainty about the capabilities of the AC17 Test. In response to suggestions that the test could not capture all possible usage conditions, EPA acknowledged that no single test procedure is likely to be capable of such performance, which was well understood at the time of its development. EPA also noted that the test represents an industry best effort at identifying a test that would greatly improve upon the range of usage conditions represented by the Idle Test, and that industry evaluation of the test shows that it achieves this objective (as well as the ability to resolve small differences in CO_2 effectiveness when carefully conducted). More discussion is found in TSD Chapter 2.2.9.1.3 at p. 2-196.

Other commenters expressed uncertainty about the use of the AC17 Test as part of the process for qualifying for and quantifying A/C efficiency menu credits beginning in MY2020. In response to a suggestion that the need to identify a baseline vehicle for A-to-B comparisons makes the test unworkable, EPA disagreed, pointing out that the regulation provides for engineering judgment when identifying a suitable baseline vehicle, and also that the engineering analysis provision under 40 CFR 86.1868-12(g)(2) provides an alternative to locating and performing an AC17 test on a baseline vehicle if such a vehicle cannot be identified. In response to comments that the process by which manufacturers may pursue the engineering analysis option should be streamlined and made clearer, EPA pointed out that we are continuing to coordinate with the SAE Cooperative Research Program (CRP) on standards for bench testing of hardware-based technologies, which would contribute to this goal. EPA also continues to believe that dialogue between EPA and industry stakeholders in the A/C credit program has been in the past, and will continue to be, an effective means toward identifying and developing practical solutions to this issue as well as other issues similar to those raised by some of the commenters. More discussion is found in TSD Chapter 2.2.9.1.3 at p. 2-196 to 2-197.

Commenters also suggested that other aspects of the credit application process should be streamlined. These comments included suggestions such as: (a) that EPA should consider joint applications by OEMs for the same A/C efficiency technology; and (b) that EPA should consider allowing suppliers to directly petition for credits and allow the approved credits to be applicable to OEMs that later adopt the technology. EPA responded by pointing out that concerns with system integration would likely make it very challenging if not impossible for a supplier, for example, to be able to demonstrate (through a hypothetical supplier-sponsored credit application) that a given A/C technology, as represented perhaps by a stock part number, would necessarily always result in the same or similar level of GHG effectiveness regardless of the vehicle on which it is installed. EPA expressed similar concerns with regard to the possibility of joint OEM applications, and stated that it remains unclear that joint applications would be practical or desirable as a means to streamline the process. More discussion can be found in TSD Chapter 2.2.9.1.3 at p. 2-198.

Summary of Comments and Responses on the Proposed Determination

EPA received comments relating to A/C efficiency from Motor and Equipment Manufacturers Association (MEMA), Mercedes-Benz, and Toyota. Additional comments relating more closely to the off-cycle credit program or to program harmonization were also received from these and other commenters and are addressed in Chapters 3.9 and 3.10, respectively.

MEMA recommended that EPA reconsider its stated intent in the Proposed Determination to cap A/C credits earned through the off-cycle petition process, and stated appreciation that EPA expects to consider the applicability of a cap on a case by case basis. MEMA also encouraged EPA to provide deference in this matter as the industry deploys such technologies. EPA addressed the application of a cap on A/C credits earned through the off-cycle process in TSD Chapter 2.2.9.1.1 at p. 2-190. EPA also stated its interest in seeing that the A/C credit program is able to operate as it was designed (TSD p. 2-197), and recognized that continued collaboration and dialogue between EPA and the industry has been an effective mechanism toward pursuing this outcome (TSD p. 2-197 and 2-199). Accordingly, EPA acknowledges that many considerations are relevant in judging and promoting the successful operation of the A/C credit program and expects to take such considerations into account where warranted.

Toyota praised EPA's collaboration with industry on issues related to A/C efficiency credits and mentioned looking forward to EPA's continued support in this matter. Toyota also stated that neither the requirement for AC17 testing nor the off-cycle provisions for non-menu A/C credits have been effective at transitioning the program to a performance basis. Toyota recommended that EPA therefore provide relief by expanding the A/C credit menu until this issue is resolved, and that relying on the off-cycle path to expand A/C credit opportunities is unrealistic. In response, EPA also looks forward to continued collaboration with industry to ensure that the A/C credit program continues to function as designed. As stated in the Proposed Determination, EPA continues to believe that expanding the A/C credit menu with new pre-approved A/C technologies is not necessary at this time. EPA also believes that the identification of non-menu technologies that might be proposed for addition to the menu, as well as the development of appropriate credit values for each, is best achieved by consideration of off-cycle applications as these technologies are identified by stakeholders wishing to receive credit. EPA also notes that the June 2016 petition by the Alliance and Global Automakers regarding certain harmonization issues of the CAFE and GHG programs includes consideration of certain A/C efficiency credit issues and improvement of the off-cycle credit approval process, as further discussed in Chapter 3.9 of this RTC document.

2.5.16.2 A/C Refrigerant Credits

Summary of Comments on the Draft TAR addressed in the Proposed Determination

Chapter 2.2.9.2 of the TSD discussed air conditioning leakage reduction and alternative refrigerants for mobile air conditioning systems and addressed comments on the Draft TAR that relate to this topic.

Regarding air conditioning refrigerants, EPA did not receive comments on our conclusions in the Draft TAR that auto manufacturers are continuing to improve the leak-tightness of their A/C systems and that many are transitioning to the use of low-GWP alternative refrigerants in a number of vehicle models. These conclusions reinforce our earlier projections that a complete transition to alternative refrigerants by MY2021 will in fact become reality (See TSD Chapter 2.9.2).

EPA received comments on the whether the supply of alternative refrigerants would be sufficient for the projected transition. Some commenters indicated that supply is still a concern, while others, including two producers of HFO-1234yf, commented that there will be sufficient supply. Moreover, some automotive manufacturers are developing systems that can safely use other substitutes, including CO_2, for which there is not a supply concern for the refrigerant. Based on all of the information before the agency, EPA concluded in the TSD (Chapter 2.9.2.2), that production plans for alternative refrigerants are in place to make available sufficient supply no later than MY2021 to meet current and projected demand domestically as well as abroad.

Summary of Comments on the Proposed Determination

Honeywell supported EPA's conclusion in the Proposed Determination that the A/C crediting system is appropriate and leading to significant GHG reductions through lower-leak A/C systems and industry adoption of lower-GWP refrigerants. Honeywell states that lower warranty costs can result, that the transition to HFO-1234yf systems has not been very difficult or costly for manufacturers (and these systems in fact can cost less than existing systems), and that this new refrigerant is easy to service in the field. Honeywell credits industry adoption of 1234yf and the EPA A/C credit system for creating sufficient demand to enable Honeywell to build a major production plant in the U.S., creating over 400 jobs and generating ancillary economic development.

Response to Comments on the Proposed Determination

EPA acknowledges Honeywell's comments about lower-leak A/C systems and lower-GWP refrigerant, including HFO-1234yf.

2.6 Criteria Emissions / Tier 3

Summary of Comments on the Draft TAR addressed in the Proposed Determination

Chapter 2.3.3.3.8 of the TSD discussed the Tier 3 emission program and how it was developed in full consideration of the GHG programs. The TSD discussion contains the agency response to comments received on this topic in the Draft TAR.

Comments on this part of the Draft TAR asserted that the ALPHA model failed to account for CO_2 and degradation of fuel economy (FE) associated with Tier 3 emission control systems, and the impact of more stringent Tier 3 evaporative emission regulations in the MTE analysis. EPA's response to these comments (starting at page 2-269) highlighted that the two programs were purposely coordinated to allow the development of the emission control hardware for both criteria emissions and GHGs to be complementary. Several technologies used to reduce GHG emissions can also reduce criteria emissions and vice-versa. For example, downsized engines being used to comply with GHG emission requirements also generally have lower engine out criteria pollutant emissions simply from the reduction in cylinders and displacement, resulting in less opportunity for release of cold start emissions which consist of hydrocarbons and other emissions such as PM. As a result, EPA determined that it was not appropriate to assume that criteria emission control strategies implemented for Tier 3 automatically result in CO_2 increases, and therefore it was not necessary to change the modeling assumptions.

Additionally, EPA's response acknowledges that evaporative emission challenges exist today; however, Tier 3 does not increase the purge requirements demanded from the existing Tier 2 program. Certainly some new technologies may reduce the opportunity to purge the canister; however, these challenges have been addressed today in many vehicle applications. Technology approaches as described in the TSD Chapter 2.3.3.3.8 at p. 2-269 have been effective at addressing the purge challenge.

We concluded in the response that the best available GDI technology has already achieved criteria pollutant standards associated with the future Tier 3 requirements. Accordingly, EPA did not accept the implication in the comment that there is a tradeoff between control of criteria pollutant emissions and CO_2 control.

<u>Summary of Comments and Responses on the Proposed Determination</u>

MECA commented that EPA should align Tier 3 PM limits with CARB LEVIII standards. This request is out of the scope of this determination; however, EPA's position and underlying data supporting the Tier 3 limits can be found in the Tier 3 final rule Technical Support Document.

MECA commented that the increase in PHEV sales MY2022+ may lead to unintended increases in VOC emissions due to sealed tanks and also issues with Tier 3 evaporative emission provisions and that EPA should commit to expedited follow-up rulemaking. EPA is assessing any potential issues with changes to evaporative emission control systems due to current and future PHEVs and will determine if test procedures appropriately protect for any unintended increases in VOC emissions. EPA and CARB have historically worked closely with manufacturers to modify test procedures in cases where historical practices no longer match the real world operating conditions of new technologies including PHEVs. If the agency determines that test procedures are no longer protective of unintended VOC emissions during refueling, operation or diurnals, EPA will investigate the extent of the issue and may propose potential solutions.

The Alliance commented that while EPA discussed options for reducing criteria and PM emissions that do not degrade GHG performance in the TSD, EPA did not address costs or implementation issues of these options. In the TSD, EPA highlighted that the Tier 3 emission standards were developed in full consideration of the GHG phase 2 standards, particularly because both programs have almost identical implementation schedules and dates (MY2017 to MY2025). The Tier 3 costs were generally determined with the expectation that phase 2 GHG technologies would be introduced in vehicles during the same time frame as the implementation of the Tier 3 emission standards. The Tier 3 cost analysis incorporated any additional cost increases (or reductions in some cases) for criteria emission controls related to new GHG technologies such as downsized turbocharged and Atkinson engines. The example in the TSD for PM control involving dual injection strategies was provided only as an example of a potential solution used in the past by a limited number of vehicles however most modern GDI injection systems and controls do not require this approach and therefore it was not a strategy included in the Tier 3 assessment or costs.

2.7 Baseline Fleet

This section reviews comments and responses on the data sources and approach used for creation of the baseline fleet.

Comments relating specifically to the representation of advanced technologies in the baseline fleet are addressed separately in Section 2.7.1 below. Comments related to EPA's inclusion of ZEV-program vehicles in the baseline are reviewed in Section 2.7.2 below.

<u>Summary of Comments on the Draft TAR addressed in the Proposed Determination</u>

TSD Chapter 1.1 discussed how EPA created the baseline fleet. Public comments on the Draft TAR that are related to the baseline fleet were discussed in Section A.2.1 of the Proposed Determination Appendix at p. A-2, and in TSD Chapter 1.1.2 beginning at p. 1-2.

Some commenters on the Draft TAR highlighted the importance of using the latest MY fleet data to create the baseline fleet. For the Draft TAR, EPA had used MY2014 certification data, which at the time was the most recent final complete data. See Draft TAR at p. 4-9. For the Proposed Determination analysis, consistent with EPA's stated preference to use the most recent model year data for which there is a complete set of certified data, EPA updated the baseline fleet to a MY2015 basis using the MY2015 GHG compliance data set, which had been completed since the Draft TAR analysis. More discussion of these comments may be found in TSD Chapter 1.1.2 at p. 1-2. EPA also made adjustments to better represent the degree to which low rolling resistance tires, aerodynamic technologies, and mass reduction had been implemented in the 2015 baseline fleet, again consistent with commenters' suggestions. See Proposed Determination Appendix A, Sections A.2.1.2 and A.2.1.3.

Other comments addressing the data used for the baseline included: concerns about the presence of vehicles that are no longer in production, a recommendation that the baseline be created using a multi-year average, and various perceived inconsistencies with contributing data sources such as IHS-Polk and EIA's AEO2015 data. With respect to vehicles that are no longer in production, EPA clarified that its projection of the future fleet is performed in a way that respects the discontinuation and succession of models within a vehicle class, a normal aspect of a manufacturer's product development. Further discussion of these comments may be found in TSD Chapter 1.1.2 at p. 1-2 to 1-3, and 1-16.

Summary and Response to Comments on the Proposed Determination

The Alliance commented, "In addition to using projections instead of actuals, EPA compounds the problem by cherry-picking projections from the Trends Report. For example, EPA relies on the projection of car market share increasing from 57.4% in MY 2015 to 62.1% in MY 2016. The 2016 Baseline Study predicts a car market share decrease to 55.7% in MY 2016." In response, EPA does not agree that it is cherry-picking projections from the Trends report. EPA has not applied any of the data from any Trends report in the creation of the MY2015 baseline used in the Proposed Determination. The process and data sources for creating the MY2015 baseline are explained in Chapter 1.1.3 of the TSD for the Proposed Determination. EPA used the Energy Information Administration (EIA) Annual Energy Outlook (AEO) 2016 for determination of the car vs. truck market share. Specifically, EPA used a customized version of EIA's 2016 annual energy outlook for car vs. truck market share for all years except for the baseline year which uses actual volumes. See TSD Chapter 1.1.3.1.1. EPA has consistently used versions of EIA's annual energy outlook in past analyses of the baseline and future fleet forecasts for vehicle GHG standards assessments, and commenters have not questioned the appropriateness of its use.

Global Automakers commented, "First, although it was appropriate for EPA to update their baseline fleet to reflect the MY 2015 vehicles, by rushing forward with the determination, the agency has foreclosed its ability to use the most up-to-date information in the Midterm Evaluation. Much of the MY 2016 fleet is now complete, and this information could be used to better inform EPA's data as well." In response, the MY2016 sales end at the end of calendar year 2016, and most manufacturers do not report their final GHG data to EPA until three months after the end of the year as stated in Chapter 1.1.3 of the Proposed Determination TSD. MY2015 is the most recent year for which final certification data is available, and EPA has used that information in the Proposed and Final Determinations (as recommended by commenters to the Draft TAR).

Additional comments related to the creation of the baseline fleet were concerned specifically with how existing technologies in the base fleet were represented. These comments are reviewed in the following section.

2.7.1 Technologies in Baseline

This chapter reviews comments and responses on the topic of technologies represented in the baseline fleet.

Summary of Comments on the Draft TAR addressed in the Proposed Determination

TSD Chapter 1.1 discussed how EPA created the baseline fleet. Public comments on the Draft TAR that are related to the baseline fleet are discussed in Section A.2.1 of the Proposed Determination Appendix at p. A-2, and in TSD Chapter 1.1.2 beginning at p. 1-2.

Some comments relating to the baseline fleet focused on how EPA accounted for technologies already implemented in the current fleet, such as low rolling resistance tires, aerodynamic drag reduction, and mass reduction. That is, that the Draft TAR analysis may have overestimated the degree to which reductions in rolling resistance and aerodynamic drag could be implemented at the estimated costs, on the grounds that some vehicles in the existing fleet have already implemented some of these technologies to varying degrees. For example, one commenter noted that EPA had acknowledged that "low rolling resistance tires are increasingly specified by OEMs in new vehicles," yet had not apparently accounted for this existing penetration of this technology in the baseline fleet. Similarly, some OEM commenters pointed out that aerodynamic improvements have been implemented in new vehicle designs over the past several years, and felt that these improvements were not adequately reflected in the Draft TAR aerodynamic technology baseline. The logic of these comments is that if the technologies are not reflected in the baseline, then the projected efficiency improvements would either not be feasible, or would be feasible only at greater cost, because more advanced technologies would be needed since the lower cost technologies would already be in baseline vehicles.

EPA agreed with many of these comments and made the types of adjustments recommended by the commenters as to how these technologies are represented in the baseline fleet in the Proposed Determination analysis.

Specifically, EPA updated its assessment of tire rolling resistance and aerodynamic drag reduction technologies by accounting for their estimated presence in the baseline fleet and modifying the permissible application of these technologies accordingly, as the commenters suggested. The accounting for rolling resistance reduction was described in Chapter 2.3.4.5 of the TSD at p. 2-410 and was also reviewed briefly in Section A.2.1 of the Proposed Determination Appendix at p. A-2 and A-3. This accounting is also reviewed in Chapter 2.5.14 of this Response to Comments (RTC) document. The accounting for aerodynamic drag reduction was described in Chapter 2.3.4.4 of the TSD and reviewed briefly in Section A.2.1 of the Proposed Determination Appendix at p. A-2 and A-3. This accounting is also reviewed in Chapter 2.5.13 of this RTC document.

Because EPA also updated its baseline fleet basis to MY2015, accounting of mass reduction present in each vehicle in the MY2015 baseline fleet was also updated. EPA performs this accounting by comparing the MY2008 version of each model to the baseline MY version (here, MY2015) according to the sales weighted average curb weights of the various trim levels, after adjusting for size, additional safety requirements, and drive type, as reviewed in Chapter 2.3.4.6.1 of the TSD at p. 2-411 to 2-412.

Summary and Response to Comments on the Proposed Determination

In comments on the Proposed Determination, Global Automakers stated, "Several errors were identified in the Proposed Determination. One example occurs in EPA's classification of Civic models which, due to the agency's methodology, resulted in a gross overestimation of hybrids (HEVs) in Honda's modeled reference fleet. EPA acknowledged the existence of this error in the Proposed Determination's TSD." In response, EPA notes that this refers to an error in the Draft TAR's MY2014 baseline that does not exist in the MY2015 baseline used for the Proposed Determination. The error resulted from a few Honda vehicles having been mislabeled. The error affected only Honda vehicles, and only in the Draft TAR analysis. The commenter's reference to "several errors" seems to point to errors described in the comments submitted by Honda on the Draft TAR, which as noted EPA has since corrected. The commenters do not specifically point to new errors introduced as part of the Proposed Determination. EPA made significant effort to prevent errors in the projection process for the MY2015 baseline used for the Proposed Determination, and has not identified any such errors in that projection data.

In commenting on the OMEGA analysis, some commenters did refer to errors in specific data. Global Automakers stated, "Some of the Proposed Determination's OMEGA data files contain what appear to be mistakes. Take EPA's modeling of electronic power steering (EPS), for example. In the Proposed Determination, EPA's baseline fleet does not include EPS for any Honda or Acura models. This is wrong and contradicts the agency's own MY 2014 baseline analysis, which applied approximately 80% penetration to the fleet. Errors in the latest OMEGA files are not limited to EPS. Other incorrectly applied technologies included aero designation (on Civic HF) and VVT application (on multiple Honda and Acura models)."

With regard to EPS, EPA obtained EPS information from the MY2015 VOLPE baseline file that was published with the Draft TAR in July of 2016. Because no commenters on the Draft TAR questioned the EPS information in that file, the information was subsequently carried over into the Proposed Determination analysis. EPA agrees that some of the vehicles in the baseline were incorrectly coded with respect to the presence of EPS. However, EPA believes that the effect of this error on projected costs is minimal and would certainly not change the conclusions of the analysis. There exists considerable technology available to compensate for the lost effectiveness improvement potential of EPS had EPS been included in the baseline. In fact, our central case run (ICM, AEO reference case fuel prices) shows that EPS penetrates the fleet at a rate above 90 percent in the reference case, with slightly more penetration in our control case.[36]

[36] EPS was not included in our detailed technology penetration rate tables presented in Section C.1.1.3 of the Proposed Determination. The technology penetration rates of all technologies, including EPS, can be found in the detailed "OMEGA-core Runs" files included in the docket and on the OMEGA webpage at https://www.epa.gov/sites/production/files/2016-11/omega-pd2016-omegacore-runs.zip. Specifically, the file named "Tables_TechPens_20161118_icm_aeoR.xlsx" (and similarly named files for each sensitivity) provides the detailed technology penetrations for all technologies.

Therefore, less than 10 percent of the reference case fleet is impacted by this EPS error. Based on the results of our other sensitivity analyses, EPA estimates that slightly more Atkinson-2, stop-start, and transmission improvements would occur with only minor cost impacts. Therefore, while we regret the error, we do not believe it has any effect on the conclusions of our assessment.

Further, with respect to aerodynamic technology on the Honda Civic HF, EPA believes that the representation of aerodynamic technology is appropriate based on EPA's estimation of aerodynamic drag performance (as represented by estimated drag area or C_dA[37]) for the vehicle. As described in Chapter 2.5.13 of this RTC document and also in the TSD as cited there, for each vehicle in the baseline, EPA accounts for the potential for additional aerodynamic improvement by placing vehicles in three bins (no aero technology, Aero1, and Aero2) by a methodology that analyzes the road load coefficients that are supplied by manufacturers for vehicle certification. In the case of the Honda Civic HF, the particular road load coefficients reported for this vehicle places it slightly short of the cutoff value for the Aero1 technology bin. The manufacturer-supplied road load coefficients for other Civic models indicated somewhat lower C-coefficients than the Civic HF, and as a result the methodology placed those variants in the Aero1 bin. As stated previously in Chapter 2.5.13 of this RTC document where the methodology is reviewed, while this method is not intended to exactly identify the specific drag reducing technologies present in any individual vehicle, EPA believes that it is effective at representing existing technology and remaining potential in aggregate across the fleet as required for the purposes of the analysis.

Regarding representation of VVT technology, EPA believes that VVT on Honda and Acura models is represented correctly per Honda's certification information and information from Ward's Automotive. Honda certified that all of its gasoline engines had VVT. EPA uses Ward's Automotive engine data as a quality control measure, and this data corroborates that all Honda engines are equipped with VVT.

Most of the data used for creation of the MY2015 baseline fleet was taken directly from manufacturer certification data, with the exception of data on valve actuation, EPS, and curb weight. Valve actuation type (OHV, SOHC, DOHC) came from Ward's Automotive and was verified by using the valves per cylinder information given in the manufacturer certification information versus the valves per cylinder information given by Ward's Automotive. EPS, as stated earlier, was not verified. Curb weight was verified by reference to publicly available information and certification data to ensure it was accurate, and in some cases was corrected. Given that the vast majority of the data in the MY2015 baseline comes directly from what manufacturers have certified their vehicles as containing, EPA believes that the data is largely accurate, aside from the EPS data that EPA acknowledges was incorrectly coded.

2.7.2 The ZEV Program in the OMEGA Analysis Fleet

Summary of Comments on the Draft TAR addressed in the Proposed Determination

In the Proposed Determination (and the Draft TAR), EPA recognized that state Zero Emission Vehicle (ZEV) regulations would result in a significant number of electrified vehicles to be present in future vehicle fleets. EPA reasoned that because these ZEVs are already required by

[37] C_dA is the product of a vehicle's coefficient of drag (C_d) and frontal area (A).

separate laws in California and nine other states, these vehicles will be part of the reference fleet by virtue of those requirements. The federal standards thus would not be imposing additional requirements or costs to these vehicles, nor would the federal standards result in benefits which would not otherwise occur. To avoid double counting, EPA thus considered these ZEV vehicles to be part of the reference fleet, and projected the number of electrified vehicles thus included.

The Alliance of Automobile Manufacturers and others commented that including electrified vehicles that result from compliance with the ZEV program as part of our reference fleet analysis was unfairly counting their benefits without estimating their costs. EPA noted that this comment is mistaken because the ZEV program vehicles are included in both the reference and control cases; therefore, EPA is neither calculating the benefits nor costs of the ZEV program as part of the MY2022-2025 standards assessment. EPA also noted that the methodology is consistent with OMB Circular A-4, which states that in developing a baseline for purposes of analyzing the potential effects of a proposed rule,"[t]his baseline should be the best assessment of the way the world would look absent the proposed action."[38] Other commenters, including the Environmental Defense Fund and the Union of Concerned Scientists, supported the inclusion of ZEV program vehicles in the reference fleet, pointing out that this approach ensures that the costs of the ZEV program, which are not imposed by the 2022-2025 standards but rather by state law, are not included as costs of the national rule. Further, in the Proposed Determination TSD at page 1-33, EPA noted that any ZEV vehicles sold in California and other states would help a manufacturer in meeting the EPA GHG standards. While the fleet-average GHG emissions standards establish minimum standards, they do not limit the ability of manufacturers to achieve further reductions, and any manufacturer that does will generate credits that can be used or sold. ZEVs sold in California and other states will help a manufacturer to meet (or exceed) the EPA GHG standards. More detail on these responses may be found in TSD Chapter 1.2.1.1 at p. 1-32.

Summary of Comments on the Proposed Determination

In comments on the Proposed Determination, several organizations provided comments relating to the inclusion of ZEV vehicles in the baseline and reference cases.

Comments from American Council for an Energy-Efficient Economy (ACEEE), Union of Concerned Scientists (UCS), Center for Biological Diversity (CBD), Natural Resources Defense Council (NRDC), and the International Council on Clean Transportation (ICCT) explicitly supported the way EPA accounted for ZEV vehicles. ACEEE echoed EPA's position that inclusion of ZEVs in the reference fleet attributes neither benefits nor costs of ZEVs to the federal program. CBD presented arguments supporting EPA's rationale for not including the costs, noting that California's program, which has also been independently adopted by several other states, is not part of the national program. NRDC states that the ZEV programs should be treated similarly to the federal Tier 3 and California LEV III standard costs, and that the ZEV programs are not GHG control programs despite their having an effect of lowering the cost of compliance with the GHG program.

Comments from Global Automakers, the Alliance, Toyota, and NADA were largely similar to comments received on the Draft TAR in that they continued to disagree with the inclusion of ZEV vehicles without accounting for their cost. The Alliance stated that EPA dismissed its

[38] Office of Management and Budget Circular No. A-4, "Regulatory Analysis," at page 15, available at https://www.whitehouse.gov/omb/memoranda_m03-21.

comments on this topic, and that EPA misunderstood its primary point that having the ZEV mandate vehicles in the reference case lowers the need for other technologies. Global also commented on inclusion of ZEV vehicles in the reference case and stated that the EPA response was insufficient. NADA stated that it supports the position of the Alliance and Global. Toyota echoed similar concerns and pointed out that the ZEV program has a history of revising its targets, suggesting that actual ZEV penetration levels are uncertain.

The Global Automakers also commented that the ZEV program requires ZEV program vehicle sales to increase to 15 percent or more by 2025. Global Automakers also argued that EPA must consider the cumulative costs and burdens of the GHG regulations, the CAFE requirements and the ZEV mandate; yet has not done so; and that EPA had included the benefits of the ZEV mandate but not the costs of the mandate. Global Automakers argued that EPA had created a reference case with lower GHG emissions than would otherwise exist, at zero cost, thereby misleadingly suggesting that manufacturers can use only lower-cost technologies to meet the federal standards.

Response to Comments on the Proposed Determination

EPA understands the comments from industry about this issue. As we see it, there are two primary issues presented in these comments: (1) the impact of the ZEV program on the cost per vehicle estimates; and (2) the impact of the ZEV program on the costs and benefits of the MY2022-2025 GHG standards. On the first issue, EPA has been clear that the presence of the ZEVs in the analysis fleet serves to reduce the cost per vehicle estimated by the analysis (see the Proposed Determination TSD at page 1-33). EPA has not quantified the small impact on cost per vehicle that occurs due to the inclusion of ZEV program vehicles. Given the ZEV program sales of roughly 420,000 vehicles projected for MY2025, and the inclusion of upstream emissions in the compliance CO_2 level of BEVs and PHEVs, we believe that the cost per vehicle would be only marginally higher were the ZEV program vehicles not included. However, we have not modeled the program in this way, since we are following the OMB guidelines for establishing an appropriate reference case reflecting "the way the world would look" absent the MY2022-2025 standards, as noted above. Since the ZEV regulations are independent of the national GHG emissions standards, these standards would be in effect even if the MY2022-2025 standards did not exist. The ZEV vehicles will in fact be part of the compliance determination for each manufacturer's fleet, and thus we have modeled them in this manner.

On the second issue, EPA has not calculated the costs or benefits of the ZEV program for California and the other states adopting the ZEV program because those costs and benefits are not imposed or realized by the GHG standards.

Regarding the comment from Global Automakers that ZEV sales must increase to 15 percent by 2025, the Draft TAR (Chapter 4.1.4.2.1) included a description of the CARB ZEV requirements. The ZEV regulation establishes a minimum number of ZEV credits that must be met, not an actual percentage of new car sales. Each ZEV earns a number of credits based on its electric range. When adopted in 2012, ARB estimated it would take approximately 15 percent of sales to be ZEVs to meet the credit requirement. However, since then, ZEV technology has advanced more rapidly than anticipated and longer range BEVs and PHEVs are already on the market, with even more announced for future release. In the original 15 percent calculation, BEVs were assumed to have a real world range of 70 miles, and accordingly earn 1.5 credits per vehicle. However, current BEVs, like many of the Tesla models and the GM Bolt EV, already have a range exceeding 200 miles and accordingly, earn more than 3 credits per vehicle. The Proposed Determination analysis, like the Draft TAR, included BEVs with a 200 mile range. Most importantly, CARB helped develop the ZEV program sales projections used in both the Draft TAR and the Proposed Determination so the percentage of the fleet made up by ZEV program vehicles is consistent with CARB's expectations at that time.

2.8 OMEGA

Summary of Comments on the Draft TAR addressed in the Proposed Determination

Comments received on the Draft TAR pertaining to EPA's OMEGA model were primarily oriented toward its modeling inputs and outputs rather than OMEGA itself or its algorithms.

While not pertaining directly to OMEGA, EPA noted that several OEM commenters suggested that they plan to expand their use of off-cycle credits in the coming years, as evidenced in part by their suggestions that EPA should consider removing the 10 g/mi cap on the use of off-cycle menu technologies. Comments regarding the 10 g/mi cap, which are an off-cycle topic, are discussed further in Chapter 3.9 of this RTC document. With regard to OMEGA, EPA recognized that the commenters' emphasis on the importance of off-cycle credits (specifically, those in the off-cycle technology menu) suggested that the OMEGA model could be improved by incorporating additional representation of the potential for off-cycle credits to contribute to potential compliance paths. In response, EPA built into OMEGA the ability to model use of two additional levels of off-cycle credits that had not been modeled in previous analyses. More discussion of this improvement may be found in the Proposed Determination Appendix A.2.7 at p. A-15 and C.1.1.1.3.

In addition to those comments addressing off-cycle technologies and credits, we also received comments on the Draft TAR suggesting that certain technologies—namely Atkinson 2 (advanced Atkinson, ATK2+cooled EGR), the most advanced transmissions (TRX22), and mass reduction—could not be adopted at the levels projected by OMEGA in the MY2022-2025 timeframe. As such, these commenters believed that the EPA analysis was relying too heavily on technologies that in their opinion could not penetrate into the fleet by MY2025, in large part due to lead time requirements and considerations related to global vehicle manufacturing and platform sharing. EPA responded generally to these comments in Chapter 2.3.1.1 of the TSD, and addressed lead time issues for specific technologies such as Atkinson 2 in the corresponding technology sections of the TSD. To further address those concerns, for the Proposed Determination we conducted several sensitivity runs that limited (i.e., artificially constrained) penetration of advanced transmissions, mass reduction, and Atkinson 2. These sensitivity cases showed that, while incremental costs did increase in some cases (e.g., the transmission-limited pathway and the Atkinson-limited pathway), they decreased in others (e.g., the mass reduction-limited pathway). Even where sensitivity cases showed incremental cost increases, compliance was still feasible and at reasonable cost. These sensitivities and their implications were described in brief in Section A.2.8 of the Proposed Determination Appendix (at p. A-16), with a full description in Sections C.1.2.1.4 and C.1.2.1.5 of the same document (at p. A-144 to A-146).

Summary of Comments on the Proposed Determination

In comments on the Proposed Determination, CARB commented, "Modeling results and technology assumptions used in the analysis are robust." Other comments relating to OMEGA were, like the Draft TAR comments, primarily concerned with specific inputs and outputs to the model, although some comment was received on the use and design of the model.

The Alliance and some individual OEMs made several comments regarding the modeling of future compliance using the OMEGA model and commented on some of the underlying inputs to the model. Specifically, the Alliance commented on the creation of a 2021 MY reference case that complies with the 2021 MY standards and the performance of the 2012 to 2016 MY fleet with respect to the EPA-projected performance in the 2010 FRM. In addition, the Alliance commented on the number of changes made to individual vehicle models being projected by OMEGA.

The Alliance also expressed concern with some aspects of the design of the OMEGA model and what it describes as its “optimized” output, stating that OMEGA “generally seems to deliver a level of fleet optimization that manufacturers cannot replicate.” They argued that OMEGA includes 7,200 vehicle technology combinations in the projected MY2025 fleet while the MY2015 baseline fleet has only 2,600, and believe that this large number of technology combinations is “not realistic from a technology investment or vehicle sales perspective.” That is, they believe that practical considerations not accounted for by the OMEGA model would prevent manufacturers from building a compliant fleet as modeled, and the fleet they could actually build would therefore be costlier than suggested by the “ideal” perspective of OMEGA.

Global Automakers comments that the “dramatic changes in the overall modeling results [between the Draft TAR and Proposed Determination] raises significant questions about the efficacy of EPA’s modeling approach,” and that it “further demonstrates that between the release of the Draft TAR and the release of the Proposed Determination, there was either (a) dramatic methodology/modeling revisions, (b) corrections to -- or incorporation of new -- data mistakes, or (c) all of the above.” They also state that “one would expect results that coalesce around certain conclusions, not ones that wildly diverge.”

Global Automakers also commented on the projected MY2025 penetration of Atkinson 2 having fallen from 44 percent in the Draft TAR to 27 percent in the Proposed Determination. They state that it is “unclear from the Proposed Determination and the TSD how EPA arrived at these changes.” Citing EPA’s description of the change in the Proposed Determination (as being the result of refinements in effectiveness modeling that more appropriately reflect the relative improvements allocated to advanced engines and transmissions in powertrain packages), they state that industry should examine whether these refinements are reasonable. They also describe the projected penetration rate of Atkinson 2 to be unreasonable given the time available.

Mercedes-Benz commented that EPA used, in the Draft TAR, both the Indirect Cost Multiplier (ICM) and Retail Price Equivalent (RPE) approaches to estimate indirect costs, and that these two approaches had produced “very different technology penetration rates for our fleets.” They described these package shifts as significant and therefore “call into question the validity of the models used to make these assessments,” and Recommended that they be “investigated and corrected.” They also said that the Proposed Determination did not discuss why with the use of RPE vs. ICM has such an impact on projections for some manufacturers. They also believe that results for the RPE case were not included in the Proposed Determination, and that they would have indicated a higher level of technology and cost if they had been. Mercedes also commented that the “large variation in agency modeling projections has made it difficult to understand how the model works and create comprehensive feedback to share with the agency in such abbreviated time frames."

Mercedes-Benz also stated the belief that EPA's conclusions regarding the need for only low levels of electrification may apply to the average U.S. fleet but do not apply to relatively low volume, luxury-oriented manufacturers such as Mercedes-Benz due to limited opportunity to spread its compliance obligations across their fleets. They argue that because they have already added more fuel- efficient technologies than many other OEMs, they will need to add more technology on its vehicles than the average U.S. fleet to avoid having to purchase credits from (and therefore subsidize) competing automakers.

Mercedes-Benz also commented that EPA included too many model variants in its projected compliance paths, stating that "it is not practical to implement so many unique configurations of vehicles, especially for a low volume manufacturer."

Comments from Toyota criticized EPA's use of MY2021 as the basis for estimating MY2025 compliance costs, arguing that this "takes 2021 model year compliance as a given" and masks what they expect to be a more challenging and costly path to MY2025 compliance than assumed in the 2012 FRM.

Toyota referred back to their comments on the Draft TAR and stated that some of their feedback had not been fully addressed in the Proposed Determination, relating to what it described as an error in allowing EPS to be applied to the LX570/Land Cruiser and the failure to account for added weight of the AERO2 package.

Toyota also asked why the Proposed Determination analysis revised the mix of passenger cars and light-duty trucks to a lower truck share (53/47 percent car/truck) than the share represented in the Draft TAR (52/48 percent car/truck) when sales trends seem to suggest the opposite trend.

General Motors also commented specifically on the differences in transmission penetration rates between the Draft TAR and Proposed Determination, both for their fleet and for the fleet as a whole.

FCA presented a chart showing that between the Draft TAR and Proposed Determination, the projected percent mass reduction for FCA's fleet increased from 5.9 percent to 11.6 percent. While the main responses to the issues raised in FCA's mass reduction-related comments are provided in Chapter 2.5.12 of this RTC document (under the topic of mass reduction), the topic of changes in projected mass reduction between the two analyses is addressed below in the context of a similar comment by Mercedes-Benz.

Response to Comments on the Proposed Determination

Mercedes-Benz questions the different technology penetration rates generated when using the ICM approach to estimating indirect costs relative to using the RPE approach, and mistakenly argues that RPE results were not included in the Proposed Determination. RPE results were included with the Proposed Determination as a sensitivity analysis. Different results with ICM vs RPE should be expected since different inputs are being used. Importantly, EPA considers the ICM approach to be the more appropriate approach and, as we explained in the Draft TAR, this position is supported by many stakeholders (see Draft TAR, Chapter 5.3.2.2). Importantly, the OMEGA runs, central and sensitivity, that we have conducted are meant to reflect possible pathways toward compliance given different sets of inputs and constraints placed on some of the more important inputs. The outputs of those runs are meant to inform as to the possible technology penetrations, costs, and environmental impacts as opposed to predicting a future outcome. EPA makes no claim that the OMEGA results reflect the exact future fleet that any given manufacturer will choose, but if the fleet were as indicated by OMEGA, we believe that the manufacturer's GHG performance and costs would be consistent with those shown in the outputs.

The Mercedes-Benz comments also claim that large differences exist between the Draft TAR and the Proposed Determination in terms of technology penetration rates, and include a chart showing the differences (Figure 5, Mercedes-Benz comments). In reviewing the Mercedes comments, EPA sees considerable consistency in many of the more important technologies. The MHEV48V penetration rates when using ICMs are quite consistent. Only the RPE case results in a notable difference, and then only for cars. For the Mercedes fleet, the MHEV48V rates range from 56 percent to 75 percent. This does not seem large given the different fleets and the different cost inputs used. For PEVs, the fleet penetration rates range from 7 to 9 percent for BEVs and 0 to 3 percent for PHEVs. Again, the difference in these results is small. The lack of penetration of BEVs or PHEVs for trucks in the Draft TAR runs is explained by the fact that we constrained the model's application of those technologies—for both ZEV program sales or for compliance—on nearly all vehicles placed on the truck standard curves. Therefore, the penetration rates would naturally be 0 percent unless there already existed some in the Mercedes-Benz baseline fleet. For stop-start, the truck penetration rates are nearly identical, while the car penetration rates change considerably depending on the run. This is most likely due to the updates made to the Atkinson 2 and TRX22 effectiveness values along with the updates made to exemplar vehicles. Note that the Draft TAR ICM run pushed the Mercedes car fleet further into TDS24 and MHEV48V. In the Proposed Determination, the ICM run pushed the Mercedes car fleet into Atkinson 2 and stop-start, and stopped short of adding as much TDS24 and MHEV48V.

Missing from the Mercedes chart is differences in mass reduction, where the Draft TAR showed the Mercedes car/truck/fleet as adding 11.5/6.8/9.7 percent mass reduction, respectively. In the Proposed Determination, those percentages were 13.4/20/16.1 percent, respectively. This difference in mass reduction penetrations would be expected to have impacts on the penetrations of other technologies and on costs. The increase in mass reduction in the Proposed Determination run would be an expected result of the placement of more vehicles, for all manufacturers, onto the unibody-based mass reduction cost curve. There are significantly different mass reduction alternatives and associated costs associated with the primary vehicle architectures of unibody vs. body-on-frame. EPA believes it is important that each vehicle's mass reduction be considered within the context of its primary body architecture. In the Proposed Determination, Mercedes' entire fleet is placed on the unibody-based mass reduction cost curve and only true pickups are placed on the body-on-frame mass reduction cost curve. All other vehicles, even those placed on the truck standard curve, are placed on the unibody-based mass reduction cost curve. Table 2-5 shows a breakdown of the percentage of each manufacturer's fleet placed on each of the mass reduction cost curves in both the Draft TAR and the Proposed Determination. As shown in Table 2-5, the cost of mass reduction for the entire Mercedes fleet is based on the lower cost unibody-based curve, resulting in mass reduction being considerably more cost effective and, hence, more mass reduction is projected for Mercedes. This is true for other manufacturers, and helps explain the increased levels of mass reduction for the FCA fleet as questioned by FCA and Global.

Table 2-5 Percentage of the Fleet Placed on the Car-based versus Truck-based Mass Reduction Cost Curve

	Draft TAR		Proposed Determination	
	Unibody Cost Curve	Body-on-frame Cost Curve	Unibody Cost Curve	Body-on-frame Cost Curve
BMW	76%	24%	100%	0%
FCA	38%	62%	83%	17%
FORD	34%	66%	74%	26%
GM	46%	54%	76%	24%
HONDA	68%	32%	100%	0%
HYUNDAI/KIA	89%	11%	100%	0%
JLR	21%	79%	100%	0%
MAZDA	91%	9%	100%	0%
MERCEDES	56%	44%	100%	0%
MITSUBISHI	96%	4%	100%	0%
NISSAN	71%	29%	93%	7%
SUBARU	95%	5%	100%	0%
TESLA	100%	0%	100%	0%
TOYOTA	67%	33%	87%	13%
VOLKSWAGEN	56%	44%	100%	0%
VOLVO	38%	62%	100%	0%
Fleet	59%	41%	89%	11%

This change also helps to explain some of the other cost differences between the Draft TAR and the Proposed Determination as highlighted by Global Automakers. Importantly, the allowance of plug-in hybrid and full electrification is consistent with the mass reduction cost curve. As a result, more vehicles placed on the truck standard curve are now allowed these levels of electrification in OMEGA where, in the Draft TAR, they were not. In the Draft TAR, these levels of electrification were limited almost exclusively to cars and the smallest of cross-over utility vehicles. In the Proposed Determination, all non-pickups are allowed to electrify. This also impacts the ZEV program vehicle fleet since many ZEVs are now placed on the truck standard curve where in the Draft TAR they were almost exclusively on the car standard curve. These changes help explain some of the cost deltas questioned by Global.

Table 2-6 shows the car/truck/fleet absolute costs in both the Draft TAR and the Proposed Determination.

Table 2-6 Absolute Per Vehicle Costs in the Draft TAR and the Proposed Determination

	Draft TAR (2013$)			Proposed Determination (2015$)			Increase (dollar basis is inconsistent)		
	Car	Truck	Fleet	Car	Truck	Fleet	Car	Truck	Fleet
BMW	$1,724	$1,942	$1,776	$2,212	$3,315	$2,467	$488	$1,373	$691
FCA	$1,789	$2,451	$2,254	$1,993	$2,566	$2,391	$204	$115	$137
FORD	$969	$1,777	$1,438	$1,203	$1,374	$1,303	$234	-$403	-$135
GM	$1,169	$2,248	$1,707	$1,293	$1,446	$1,368	$124	-$802	-$339
HONDA	$842	$967	$901	$880	$1,133	$1,003	$38	$166	$102
HYUNDAI/KIA	$1,447	$2,128	$1,529	$1,386	$1,584	$1,418	-$61	-$544	-$111
JLR	$5,090	$3,436	$3,782	$1,982	$3,377	$3,090	-$3,108	-$59	-$692
MAZDA	$772	$1,081	$866	$674	$1,300	$909	-$98	$219	$43
MERCEDES	$2,482	$2,732	$2,577	$2,217	$3,028	$2,551	-$265	$296	-$26
MITSUBISHI	$1,178	$1,333	$1,234	$1,590	$1,742	$1,649	$412	$409	$415
NISSAN	$1,148	$1,526	$1,298	$1,207	$1,669	$1,383	$59	$143	$85
SUBARU	$686	$691	$690	$720	$888	$852	$34	$197	$162
TESLA	$140	$0	$140	$143	$143	$143	$3	$143	$3
TOYOTA	$884	$1,547	$1,184	$838	$1,482	$1,123	-$46	-$65	-$61
VOLKSWAGEN	$2,751	$2,560	$2,679	$2,441	$3,869	$2,879	-$310	$1,309	$200
VOLVO	$2,351	$3,170	$2,777	$1,120	$2,084	$1,607	-$1,231	-$1,086	-$1,170
Fleet	$1,293	$1,864	$1,565	$1,327	$1,740	$1,521	$34	-$124	-$44

The most obvious change between the two analyses is to JLR car costs, decreasing from $5000 to $3100. This is largely due to the reduced BEV penetration of the JLR car fleet in the Proposed Determination where the technology penetration was 2 percent while in the Draft TAR it was 30 percent. This large reduction in BEV penetration is in part due to the truck BEV penetration having increased from 0 to 7 percent, since many trucks were "allowed" to electrify in the Proposed Determination analysis while there existed more restrictions on electrification of vehicles placed on the truck standard curve in the Draft TAR. This begs the question of why there was not a large increase in JLR truck costs. This is due to the decreased mass reduction costs, since JLR's entire truck fleet is placed on the unibody cost curve. Further, JLR's baseline level of mass reduction on trucks in the Draft TAR was 11.9 percent, while in the Proposed Determination it was 3.6 percent. That alone would serve to make mass reduction on JLR trucks much costlier in the Draft TAR than in the Proposed Determination. If we look at JLR's achieved CO_2 levels, they were at 102 grams/mile in the Draft TAR and just 192 grams per mile in the Proposed Determination. In the Draft TAR, with zero upstream emissions on BEVs, OMEGA found BEVs to be an attractive means of compliance for JLR. In the Proposed Determination, which unlike the Draft TAR includes an accounting for upstream emissions in compliance calculations, those BEVs became less attractive, especially when truck mass reduction was less costly due to use of the unibody cost curve.

Global also highlighted Ford's cost changes. The Ford truck cost decrease is due largely to many of Ford's trucks being placed on the unibody cost curve. In the Draft TAR, nearly all of

Ford's trucks were placed on the body-on-frame cost curve. For some of these trucks, such as the small SUV Ford Escape, this placement was inappropriate. Ford's Escapes applied a full 5 percent more mass reduction in the Proposed Determination and for lower costs than in the Draft TAR. As for Ford cars, their achieved CO_2 has decreased from 166 g/mi to 161 g/mi, so more control has been placed on Ford cars in the Proposed Determination, most likely due to the inclusion of upstream emissions on PEVs.

For BMW, the increased car costs appear to be the result of BMW's projected penetration of PEVs for meeting the standards in both the Draft TAR and the Proposed Determination, although more of it in the Proposed Determination due to the inclusion of upstream emissions. In the Proposed Determination, the bulk of that electrification is occurring in the truck fleet (which was not allowed in the Draft TAR), which serves to increase truck costs. This requires less electrification in the car fleet but BMW has pushed further into turbo/downsizing on their car fleet in the Proposed Determination, including a 12 percent penetration of Miller-cycle where the Draft TAR had none. These serve to increase somewhat the BMW car costs.

For VW, the car costs have decreased due to less electrification (from 14 percent down to 5 percent) while the truck costs have increased due to increased electrification (from 0 percent to 18 percent).

The Volvo changes are also quite large. This appears to be largely the result of Volvo's baseline mass reduction level having been characterized as 6/7 percent and 3.8 percent for cars and trucks, respectively, in the Draft TAR, and then 2.9 percent and 0.0 percent for cars and trucks, respectively, in the Proposed Determination. This, along with the movement of vehicles from the body-on-frame mass reduction cost curve to the unibody cost curve has resulted in considerable changes to the Volvo estimates.

Global also highlighted some other differences by focusing on percentage changes between the Draft TAR and the Proposed Determination, such as Honda trucks increasing 47 percent and Mazda cars decreasing 35 percent. However, in absolute dollar terms, those changes were just $166 and $98, respectively, which again seem relatively consistent in EPA's view and not significantly changed as argued by Global. We do not mean to imply that $200 is a trivial amount; however, $200 is less than 25 percent of our incremental cost estimate of $875/vehicle and just 13 percent of our absolute cost estimate of $1521/vehicle. EPA believes the relative consistency in the combined fleet costs per vehicle is important to consider given the role credit transfers play in OMEGA which can drive fluctuations in the car/truck share of those combined fleet costs. While there are differences, many manufacturer's combined fleet costs have remained within $200 per vehicle which EPA believes represents a reasonable consistency given that we are projecting forward 11 and 10 model years from our MY2014 and MY2015 based baseline fleets.

It is also important to point out that we conducted a sensitivity that allowed no additional mass reduction beyond that in the baseline fleet. So, while the use of the lower cost unibody mass reduction curve on a higher percentage of the fleet in the Proposed Determination has a significant impact on technology penetrations and costs, the impact of using different costs should not be higher than the impacts of the sensitivity that allowed no additional mass reduction beyond that in the baseline fleet.

An important takeaway from these comparisons between the Draft TAR and the Proposed Determination is the amount of available technology with similar cost effectiveness characteristics. The relative similarities of these technologies in terms of cost effectiveness along with EPA's allowance of transfers between car/truck fleets can mean that even very small changes in technology cost and effectiveness can lead to changes in the technology penetrations of other technologies with similar cost-effectiveness, but the fleet costs and the conclusions that can be drawn from the results have remained relatively consistent throughout our analyses.

Mercedes and the automaker associations also were critical of the amount of variation in their fleets as projected by OMEGA. We disagree with the suggestion that there is a proliferation of variation and believe that the perception expressed by these commenters stems from a misunderstanding or misinterpretation of results relative to the manner in which EPA interprets the results. OMEGA is not meant to reflect a movement of each individual vehicle through the design process, year-over-year, toward compliance with the standards. OMEGA is meant to be a single model year's optimized look at the technology application and associated costs capable of delivering compliance with the standards. As a result, while OMEGA output files show individual vehicles containing sometimes multiple packages of technology, the fact is that OMEGA works on platforms (these are OMEGA platforms and not necessarily what an automaker would call a platform) containing many vehicles and applies technology to those platforms. OMEGA is indifferent as to which individual vehicles within the given platform actually apply the technology. For example, assume an OMEGA platform contained two vehicles, each a 50 percent sales share within the platform, and OMEGA converted 50 percent of that platform to a turbocharged/downsized configuration. One could interpret that to mean that half of each vehicle on the platform is converted, or that all of one vehicle was converted while the other remained unchanged. As said, OMEGA is indifferent to this. OMEGA would generate output files that show the technology penetration as half of each vehicle being converted. However, this is not necessarily the case – it is but one interpretation of the output. The OMEGA code necessary to generate these technology tracking output files was developed after completion of the 2012 FRM and was done only in an effort to make technology penetration rates more easily gleaned from a given run; the code and its output file was not meant to suggest *the* actual application of each technology to each individual vehicle but rather *one possible* application of each technology to each individual vehicle.

That being said, EPA believes that a more reasonable approach when considering proliferation of technology is to look at engine/transmission combinations within the OMEGA baseline and compare that to the combinations in the OMEGA control case. For this look, EPA has focused on the ICM, AEO reference fuel price run. We have considered the effective and actual number of cylinders (which includes the presence or lack of turbocharging), the valvetrain configuration (DOHC, SOHC, OHV) and the transmission type in terms of the TRX11 through TRX22 coding used for modeling. We have also considered as unique "platforms" all hybrid, plug-in hybrid and battery electric vehicles. In other words, these are the engine-transmission pairings in the OMEGA baseline and control case fleets. We have not considered as unique "platforms" any vehicles with stop-start or mild hybrid technology because we consider those technologies to be relatively easy to add to vehicles as necessary for improving CO_2 performance.

Some background first on "OMEGA platforms." An OMEGA platform is determined by the OEM, the curb weight class (CWC), the vehicle type (1 through 29) and the car/truck determination. One example would be the BMW_CWC2_15C which would represent a BMW car in curb weight class 2 mapped to vehicle type 15. True OEM platforms are generally determined by common mechanical elements, such as: floor pan, wheelbase, steering mechanism, suspension type, engine type/placement; transmission type/placement. As a result, a sedan and coupe and even a crossover utility vehicle might be built on the same platform provided their wheelbases, suspension, engine and transmissions were similar. For example, the Ford Focus, Escape, C-Max and Transit Connect are built on the same platform. Importantly, while built on the same platform, there could be as many as 4 or 5 different engines and 2 or 3 transmissions available for this set of vehicles.

The point here is that OEM and OMEGA platforms are not one-to-one, and were never intended to be. In the Ford example above, the Focus and Escape are clearly different curb weight vehicles despite being built on the same platform. In OMEGA, the curb weight differences would result in different OMEGA platforms. OMEGA needs that difference for determining different effectiveness values for the different curb weight classes.

The automaker comments focus on the large number of technology combinations resulting from the OMEGA runs. The Alliance argues that the baseline fleet consists of 2,600 vehicles and moves to 7,200 vehicles in the control case run, a near tripling of technology combinations. The methodology used in their determination of 7,200 vehicles, was not documented in the comment. However, if we look at our baseline fleet and break that fleet into different OEM/engine/transmission groupings, where the engine determination consists of actual number of cylinders, effective number of cylinders (i.e., a turbo charged 4 cylinder engine would be considered to have an effective 6 cylinders), valvetrain configuration (DOHC, SOHC, OHV), and transmission (consists of type (manual, automated manual, automatic, continuously variable) and number of gears), the baseline fleet would have 183 unique combinations. Again, these are not meant to reflect OEM platforms, nor are they OMEGA platforms since the curb weight class is not included.[39]

As this exercise clearly demonstrates, there exists considerable variety in the baseline fleet. Table 2-7 shows each manufacturer's baseline and control case fleets broken into categories of engines treated within OMEGA as 4, 6 and 8 cylinder engines, diesels, plug-in hybrids and battery electric vehicles. A quick look at the FCA baseline fleet shows considerable variety with four-cylinder dual-overhead cam engines equipped with four different transmissions and four cylinder single overhead-cam engines equipped with three different transmissions. OMEGA chooses to simplify this variety by converting FCA's four-cylinder fleet to Atkinson 2 while also maintaining two transmissions.

There are also cases where OMEGA increases variability in the fleet; however, manufacturers are expected to manage their product plans and compliance strategy, among other factors such as customer preference, to keep their costs to a minimum. An example of this is GM's four-cylinder

[39] Note that, when running OMEGA, there are 294 unique platforms stemming from the characterization of the pre-ZEV fleet due to the inclusion of curb weight class in the platform determination. Of that 294, 253 serve as possible ZEV-source platforms for modeling in OMEGA (i.e., 253 are non-pickup truck and non-EV/non-PHEV in the baseline). We then add 253 OMEGA platforms to reflect ZEV program BEVs and 253 more OMEGA platforms reflect the ZEV program PHEVs stemming from the 253 ZEV-source platforms, the end result being 800 unique OMEGA platforms. By doing this, we are not suggesting that ZEV program vehicles will be built on unique OEM platforms. Their platforms are unique within OMEGA only for modeling purposes within OMEGA.

vehicles. In the baseline, GM has four-cylinder vehicles with three different transmissions. After running OMEGA, two of those engines remain and the third has improved its transmission from TRX21 to TRX22. In addition, OMEGA has converted some engines to Atkinson-2 with two different transmissions. So, GM's four-cylinder engines have gone from three engine/transmission combinations to five. However, in reality, GM could move all four-cylinder engines to Atkinson 2, at some cost but also at a lowering of their fleet CO_2. The lowering of their fleet CO_2 on those four-cylinder engines could allow for less technology on some six- or eight-cylinder engines, thereby reducing six- and eight-cylinder engine costs and, thereby offsetting the increased costs on four-cylinder engines. The costs may or may not perfectly balance, but that is part of the optimization goal of OMEGA – to seek the most cost-effective approach to compliance. Given the variety in six- and eight-cylinder engine/transmission pairings in GM's baseline fleet, OMEGA's move to five such pairings in the four-cylinder control case does not appear unreasonable.

Most cases where OMEGA has increased variety compared to the baseline fleet are for those manufacturers that offer several transmissions in the baseline fleet. For the most part, OMEGA leaves 6 speed manual transmissions alone under the assumption that manufacturers offer those transmissions because some buyers insist on them. Since OMEGA leaves them alone, the control case fleet will generally have at least as many transmission offerings as were present in the baseline fleet (with the exception of movement away from any transmissions having less than six gears, denoted as TRX00 in Table 2-7).

Table 2-7 OEM, Engine Technology and Transmission Pairings in the OMEGA Baseline (pre-ZEV) and the OMEGA Control Case Fleets

OEM	General Engine	OMEGA Baseline	OMEGA Control in 2025
BMW	Engines treated as 4 cylinders	BMW_E04_A04_DOHC_M6 BMW_E04_A04_DOHC_TRX11	BMW_E04_A04_ATK2_DOHC_M6 BMW_E04_A04_ATK2_DOHC_TRX22
	Engines treated as 6 cylinders	BMW_E05_A03_TDS18_DOHC_M6 BMW_E05_A03_TDS18_DOHC_TRX11 BMW_E06_A04_TDS18_DOHC_M6 BMW_E06_A04_TDS18_DOHC_TRX11 BMW_E06_A04_TDS18_DOHC_TRX21	BMW_E06_A04_TDS18_DOHC_M6 BMW_E06_A04_TDS18_DOHC_TRX22 BMW_E06_A04_TDS24_DOHC_M6 BMW_E06_A04_TDS24_DOHC_TRX22 BMW_E06_A06_ATK2_DOHC_M6 BMW_E06_A06_ATK2_DOHC_TRX22
	Engines treated as 8 cylinders	BMW_E08_A06_TDS18_DOHC_M6 BMW_E08_A06_TDS18_DOHC_TRX11 BMW_E08_A06_TDS18_DOHC_TRX21 BMW_E08_A06_P2_TDS18_DOHC_TRX21 BMW_E10_A08_TDS18_DOHC_M6 BMW_E10_A08_TDS18_DOHC_TRX21 BMW_E14_A12_TDS18_DOHC_TRX21 BMW_E12_A12_DOHC_TRX21	BMW_E08_A06_TDS18_DOHC_TRX21 BMW_E08_A08_DOHC_TRX22 BMW_E08_A08_ATK2_DOHC_TRX22 BMW_E08_A08_ATK2_TURBM_DOHC_M6 BMW_E08_A08_ATK2_TURBM_DOHC_TRX22
	Diesels	BMW_E06_A04_DOHC_DSL_TRX21 BMW_E08_A06_DOHC_DSL_TRX21	BMW_E06_A04_DSL_TRX22 BMW_E08_A06_DSL_TRX22
	EV & PHEV	BMW_E02_A02_SOHC_REEV40 BMW_E05_A03_TDS18_DOHC_REEV40 BMW_EV75	BMW_REEV40 BMW_E04_A04_TDS18_REEV40 BMW_EV75 BMW_EV100 BMW_EV200 (ZEV)

FCA	Engines treated as 4 cylinders	FCA_E04_A04_DOHC_TRX00 FCA_E04_A04_DOHC_M6 FCA_E04_A04_DOHC_TRX11 FCA_E04_A04_DOHC_TRX21 FCA_E04_A04_SOHC_M6 FCA_E04_A04_SOHC_TRX11 FCA_E04_A04_SOHC_TRX21	FCA_E04_A04_ATK2_DOHC_M6 FCA_E04_A04_ATK2_DOHC_TRX22
	Engines treated as 6 cylinders	FCA_E06_A04_TDS18_DOHC_TRX11 FCA_E06_A04_TDS18_SOHC_M6 FCA_E06_A04_TDS18_SOHC_TRX11 FCA_E06_A06_DOHC_TRX00 FCA_E06_A06_DOHC_M6 FCA_E06_A06_DOHC_TRX11 FCA_E06_A06_DOHC_TRX21	FCA_E06_A04_TDS18_DOHC_M6 FCA_E06_A04_TDS18_DOHC_TRX22 FCA_E06_A04_TDS24_DOHC_M6 FCA_E06_A04_TDS24_DOHC_TRX22 FCA_E06_A06_ATK2_DOHC_M6 FCA_E06_A06_ATK2_DOHC_TRX22
	Engines treated as 8 cylinders	FCA_E08_A08_DOHC_TRX11 FCA_E08_A08_xOHV_M6 FCA_E08_A08_xOHV_TRX11 FCA_E08_A08_xOHV_TRX21 FCA_E08_A06_DOHC_TRX21 FCA_E10_A10_xOHV_M6 FCA_E10_A08_TDS18_xOHV_M6 FCA_E10_A08_TDS18_xOHV_TRX21 FCA_E10_A08_TDS18_DOHC_TRX21	FCA_E08_A08_OHV_M6 FCA_E08_A08_OHV_TRX22 FCA_E08_A08_DOHC_TRX22 FCA_E08_A08_ATK2_DOHC_TRX22 FCA_E08_A08_ATK2_TURBM_DOHC_TRX22 FCA_E08_A06_TDS18_DOHC_TRX22 FCA_E08_A06_TDS24_DOHC_TRX22
	Diesels	FCA_E08_A06_DOHC_DSL_TRX21	FCA_E08_A06_DSL_TRX22
	EV & PHEV	FCA_EV75	FCA_EV75 FCA_EV200 (ZEV) FCA_REEV40 (ZEV)
Ford	Engines treated as 4 cylinders	Ford_E04_A04_DOHC_M6 Ford_E04_A04_DOHC_TRX11 Ford_E04_A04_DOHC_TRX21 Ford_E04_A04_P2_TRX21	Ford_E04_A04_DOHC_M6 Ford_E04_A04_DOHC_TRX22 Ford_E04_A04_ATK2_DOHC_TRX22 Ford_E04_A04_P2_TRX21
	Engines treated as 6 cylinders	Ford_E05_A03_TDS18_DOHC_M6 Ford_E06_A04_TDS18_DOHC_M6 Ford_E06_A04_TDS18_DOHC_TRX11 Ford_E06_A06_DOHC_M6 Ford_E06_A06_DOHC_TRX11	Ford_E06_A04_TDS18_DOHC_M6 Ford_E06_A04_TDS18_DOHC_TRX22
	Engines treated as 8 cylinders	Ford_E08_A06_TDS18_DOHC_TRX11 Ford_E08_A08_DOHC_M6 Ford_E08_A08_DOHC_TRX11 Ford_E10_A08_TDS18_DOHC_M6 Ford_E10_A08_TDS18_DOHC_TRX11	Ford_E08_A06_TDS18_DOHC_TRX22 Ford_E08_A08_DOHC_M6 Ford_E08_A08_DOHC_TRX22 Ford_E08_A08_ATK2_DOHC_TRX22
	EV & PHEV	Ford_E04_A04_DOHC_REEV40 Ford_EV75	Ford_REEV40 Ford_EV75 Ford_EV200 (ZEV)
GM	Engines treated as 4 cylinders	GM_E04_A04_DOHC_M6 GM_E04_A04_DOHC_TRX11 GM_E04_A04_DOHC_TRX21	GM_E04_A04_DOHC_M6 GM_E04_A04_DOHC_TRX11 GM_E04_A04_DOHC_TRX22 GM_E04_A04_ATK2_DOHC_M6 GM_E04_A04_ATK2_DOHC_TRX22

	Engines treated as 6 cylinders	GM_E06_A04_TDS18_DOHC_M6 GM_E06_A04_TDS18_DOHC_TRX11 GM_E06_A06_DOHC_M6 GM_E06_A06_DOHC_TRX11 GM_E06_A06_DOHC_TRX21 GM_E06_A06_xOHV_TRX11	GM_E06_A04_TDS18_DOHC_M6 GM_E06_A04_TDS18_DOHC_TRX22 GM_E06_A06_OHV_TRX22
	Engines treated as 8 cylinders	GM_E08_A06_TDS18_DOHC_TRX21 GM_E08_A06_TDS18_DOHC_TRX11 GM_E08_A08_xOHV_M6 GM_E08_A08_xOHV_TRX11 GM_E08_A08_xOHV_TRX21 GM_E10_A08_TDS18_xOHV_M6 GM_E10_A08_TDS18_xOHV_TRX11 GM_E10_A08_TDS18_xOHV_TRX21	GM_E08_A06_TDS18_DOHC_TRX22 GM_E08_A08_OHV_TRX22
	Diesels	GM_E06_A04_DOHC_DSL_TRX11	GM_E06_A04_DSL_TRX22
	EV & PHEV	GM_E04_A04_REEV40 GM_EV75	GM_REEV40 GM_EV75 GM_EV200 (ZEV)
Honda	Engines treated as 4 cylinders	Honda_E04_A04_DOHC_TRX00 Honda_E04_A04_SOHC_TRX00 Honda_E04_A04_SOHC_M6 Honda_E04_A04_SOHC_TRX21 Honda_E04_A04_DOHC_M6 Honda_E04_A04_DOHC_TRX21 Honda_E04_A04_SOHC_TRX21 Honda_E04_A04_P2_M6 Honda_E04_A04_P2_TRX21	Honda_E04_A04_DOHC_M6 Honda_E04_A04_DOHC_TRX22 Honda_E04_A04_ATK2_DOHC_M6 Honda_E04_A04_ATK2_DOHC_TRX22 Honda_E04_A04_P2_M6 Honda_E04_A04_P2_TRX21
	Engines treated as 6 cylinders	Honda_E06_A06_SOHC_TRX00 Honda_E06_A06_SOHC_M6 Honda_E06_A06_SOHC_TRX11 Honda_E06_A06_SOHC_TRX21	Honda_E06_A06_DOHC_M6 Honda_E06_A06_DOHC_TRX22
	Engines treated as 8 cylinders	None	None
	EV & PHEV	None	Honda_EV200 (ZEV) Honda_REEV40 (ZEV)
Hyundai/ Kia	Engines treated as 4 cylinders	Hyundai/Kia_E04_A04_DOHC_M6 Hyundai/Kia_E04_A04_DOHC_TRX11 Hyundai/Kia_E04_A04_P2_TRX11	Hyundai/Kia_E04_A04_DOHC_M6 Hyundai/Kia_E04_A04_DOHC_TRX21 Hyundai/Kia_E04_A04_DOHC_TRX22 Hyundai/Kia_E04_A04_ATK2_DOHC_M6 Hyundai/Kia_E04_A04_ATK2_DOHC_TRX22 Hyundai/Kia_E04_A04_P2_TRX11
	Engines treated as 6 cylinders	Hyundai/Kia_E06_A04_TDS18_DOHC_M6 Hyundai/Kia_E06_A04_TDS18_DOHC_TRX11 Hyundai/Kia_E06_A04_TDS18_DOHC_TRX21 Hyundai/Kia_E06_A06_DOHC_M6 Hyundai/Kia_E06_A06_DOHC_TRX11 Hyundai/Kia_E06_A06_DOHC_TRX21	Hyundai/Kia_E06_A04_TDS18_DOHC_M6 Hyundai/Kia_E06_A04_TDS18_DOHC_TRX22
	Engines treated as 8 cylinders	Hyundai/Kia_E08_A08_DOHC_TRX21	Hyundai/Kia_E08_A08_DOHC_TRX22
	EV & PHEV	Hyundai/Kia_EV75	Hyundai/Kia_EV75

			Hyundai/Kia_EV200 (ZEV) Hyundai/Kia_REEV40 (ZEV)
JLR	Engines treated as 4 cylinders	None	None
	Engines treated as 6 cylinders	JLR_E06_A04_TDS18_DOHC_TRX21	JLR_E06_A04_TDS18_DOHC_TRX22 JLR_E06_A04_TDS24_DOHC_TRX22
	Engines treated as 8 cylinders	JLR_E08_A06_TDS18_DOHC_TRX21 JLR_E08_A08_DOHC_TRX11 JLR_E10_A08_TDS18_DOHC_TRX11 JLR_E10_A08_TDS18_DOHC_TRX21	JLR_E08_A06_TDS18_DOHC_TRX22 JLR_E08_A08_DOHC_TRX22 JLR_E08_A08_ATK2_DOHC_TRX22 JLR_E08_A08_ATK2_TURBM_DOHC_TRX22
	EV & PHEV	None	JLR_EV75 JLR_EV100 JLR_EV200 (ZEV) JLR_REEV40 (ZEV)
Mazda	Engines treated as 4 cylinders	Mazda_E04_A04_DOHC_M6 Mazda_E04_A04_DOHC_TRX00 Mazda_E04_A04_DOHC_TRX11 Mazda_E04_A04_ATK2_DOHC_M6 Mazda_E04_A04_ATK2_DOHC_TRX11	Mazda_E04_A04_DOHC_M6 Mazda_E04_A04_DOHC_TRX22 Mazda_E04_A04_ATK2_DOHC_M6 Mazda_E04_A04_ATK2_DOHC_TRX21 Mazda_E04_A04_ATK2_DOHC_TRX22
	Engines treated as 6 cylinders	Mazda_E06_A06_DOHC_TRX11	Mazda_E06_A04_TDS18_DOHC_TRX22
	Engines treated as 8 cylinders	None	None
	EV & PHEV	None	Mazda_EV200 (ZEV) Mazda_REEV40 (ZEV)
Mercedes	Engines treated as 4 cylinders	Mercedes_E03_A03_DOHC_TRX00	Mercedes_E04_A04_ATK2_DOHC_TRX22
	Engines treated as 6 cylinders	Mercedes_E06_A04_TDS18_DOHC_M6 Mercedes_E06_A04_TDS18_DOHC_TRX21 Mercedes_E06_A06_TDS18_DOHC_TRX21 Mercedes_E06_A06_P2_DOHC_TRX21	Mercedes_E06_A04_TDS18_DOHC_M6 Mercedes_E06_A04_TDS18_DOHC_TRX22 Mercedes_E06_A04_TDS24_DOHC_TRX22 Mercedes_E06_A06_ATK2_DOHC_M6 Mercedes_E06_A06_ATK2_DOHC_TRX22 Mercedes_E06_A06_P2_TRX21
	Engines treated as 8 cylinders	Mercedes_E08_A06_TDS18_DOHC_TRX21 Mercedes_E08_A08_DOHC_TRX21 Mercedes_E08_A08_SOHC_TRX21 Mercedes_E10_A08_TDS18_DOHC_TRX21 Mercedes_E14_A12_TDS18_SOHC_TRX21 Mercedes_E14_A12_TDS18_DOHC_TRX21	Mercedes_E08_A06_ATK2_TURBM_DOHC_TRX22 Mercedes_E08_A08_DOHC_TRX22 Mercedes_E08_A08_SOHC_TRX22 Mercedes_E08_A08_ATK2_DOHC_TRX22 Mercedes_E08_A08_ATK2_TURBM_DOHC_TRX22 Mercedes_E08_A08_P2_TRX22
	Diesels	Mercedes_E06_A04_DOHC_DSL_TRX21 Mercedes_E08_A06_DOHC_DSL_TRX21	Mercedes_E06_A04_DSL_TRX22 Mercedes_E08_A06_DSL_TRX22
	EV & PHEV	Mercedes_E08_A06_TDS18_REEV40 Mercedes_EV75	Mercedes_TDS18_REEV40_TRX21 Mercedes_EV75 Mercedes_EV100 Mercedes_EV200

Mitsubishi	Engines treated as 4 cylinders	Mitsubishi_E03_A03_DOHC_M6 Mitsubishi_E03_A03_DOHC_TRX21 Mitsubishi_E04_A04_SOHC_M6 Mitsubishi_E04_A04_SOHC_TRX21	Mitsubishi_E04_A04_DOHC_M6 Mitsubishi_E04_A04_DOHC_TRX22 Mitsubishi_E04_A04_ATK2_DOHC_M6 Mitsubishi_E04_A04_ATK2_DOHC_TRX22
	Engines treated as 6 cylinders	Mitsubishi_E06_A04_TDS18_SOHC_M6 Mitsubishi_E06_A06_SOHC_TRX11 Mitsubishi_E06_A04_TDS18_SOHC_TRX11	Mitsubishi_E06_A04_TDS18_DOHC_M6 Mitsubishi_E06_A04_TDS18_DOHC_TRX22
	Engines treated as 8 cylinders	None	None
	EV & PHEV	None	Mitsubishi_EV200 (ZEV) Mitsubishi_REEV40 (ZEV)
Nissan	Engines treated as 4 cylinders	Nissan_E04_A04_DOHC_TRX00 Nissan_E04_A04_DOHC_M6 Nissan_E04_A04_DOHC_TRX21	Nissan_E04_A04_DOHC_M6 Nissan_E04_A04_DOHC_TRX22 Nissan_E04_A04_ATK2_DOHC_M6 Nissan_E04_A04_ATK2_DOHC_TRX22 Nissan_E04_A04_TDS18_DOHC_M6 Nissan_E04_A04_TDS18_DOHC_TRX22
	Engines treated as 6 cylinders	Nissan_E06_A04_TDS18_DOHC_M6 Nissan_E06_A04_TDS18_DOHC_TRX21 Nissan_E06_A04_P2_TDS18_DOHC_TRX21 Nissan_E06_A06_DOHC_TRX00 Nissan_E06_A06_DOHC_M6 Nissan_E06_A06_DOHC_TRX21 Nissan_E06_A06_P2_DOHC_TRX21	Nissan_E06_A04_TDS18_DOHC_M6 Nissan_E06_A04_TDS18_DOHC_TRX22 Nissan_E06_A04_TDS24_DOHC_TRX22 Nissan_E06_A04_TDS18_P2_TRX21 Nissan_E06_A06_P2_TRX21
	Engines treated as 8 cylinders	Nissan_E08_A06_TDS18_DOHC_TRX11 Nissan_E08_A08_DOHC_TRX00 Nissan_E08_A08_DOHC_TRX21	Nissan_E08_A08_DOHC_TRX22 Nissan_E08_A08_ATK2_DOHC_TRX22 Nissan_E08_A06_TDS18_DOHC_TRX22
	EV & PHEV	Nissan_E75	Nissan_EV75 Nissan_EV200 (ZEV) Nissan_REEV40 (ZEV)
Subaru	Engines treated as 4 cylinders	Subaru_E04_A04_DOHC_M6 Subaru_E04_A04_DOHC_TRX11 Subaru_E04_A04_DOHC_TRX21 Subaru_E04_A04_P2_DOHC_TRX21	Subaru_E04_A04_DOHC_M6 Subaru_E04_A04_DOHC_TRX21 Subaru_E04_A04_DOHC_TRX22 Subaru_E04_A04_ATK2_DOHC_M6 Subaru_E04_A04_ATK2_DOHC_TRX22 Subaru_E04_A04_P2_TRX21
	Engines treated as 6 cylinders	Subaru_E06_A04_TDS18_DOHC_M6 Subaru_E06_A04_TDS18_DOHC_TRX21 Subaru_E06_A06_DOHC_TRX21	Subaru_E06_A04_TDS18_DOHC_M6 Subaru_E06_A04_TDS18_DOHC_TRX22
	Engines treated as 8 cylinders	None	None
	EV & PHEV	None	Subaru_EV200 (ZEV) Subaru_REEV40 (ZEV)
Tesla	EV & PHEV	Tesla_EV200	Tesla_EV200
Toyota	Engines treated as 4 cylinders	Toyota_E04_A04_DOHC_TRX00 Toyota_E04_A04_DOHC_M6 Toyota_E04_A04_DOHC_TRX11 Toyota_E04_A04_DOHC_TRX21 Toyota_E04_A04_P2_DOHC_TRX21	Toyota_E04_A04_DOHC_M6 Toyota_E04_A04_DOHC_TRX21 Toyota_E04_A04_DOHC_TRX22 Toyota_E04_A04_ATK2_DOHC_TRX22 Toyota_E04_A04_P2_TRX21

	Engines treated as 6 cylinders	Toyota_E06_A04_TDS18_DOHC_TRX11 Toyota_E06_A06_DOHC_TRX00 Toyota_E06_A06_DOHC_M6 Toyota_E06_A06_DOHC_TRX11 Toyota_E06_A06_DOHC_TRX21 Toyota_E06_A06_P2_DOHC_TRX21	Toyota_E06_A04_TDS18_DOHC_M6 Toyota_E06_A04_TDS18_DOHC_TRX22 Toyota_E06_A06_P2_TRX21
	Engines treated as 8 cylinders	Toyota_E08_A08_DOHC_TRX11 Toyota_E08_A08_DOHC_TRX21 Toyota_E08_A08_P2_DOHC_TRX21	Toyota_E08_A08_DOHC_TRX22 Toyota_E08_A08_ATK2_DOHC_TRX22 Toyota_E08_A08_P2_TRX21
	EV & PHEV	Toyota_E04_A04_REEV40_DOHC_TRX21	Toyota_REEV40 Toyota_EV200 (ZEV)
VW	Engines treated as 4 cylinders	Volkswagen_E04_A04_SOHC_M6 Volkswagen_E04_A04_SOHC_TRX11	VW_E04_A04_ATK2_DOHC_TRX22
	Engines treated as 6 cylinders	Volkswagen_E06_A04_TDS18_DOHC_M6 Volkswagen_E06_A04_TDS18_DOHC_TRX11 Volkswagen_E06_A04_TDS18_DOHC_TRX21 Volkswagen_E06_A04_P2_TDS18_DOHC_TRX21 Volkswagen_E06_A04_TDS18_SOHC_TRX21 Volkswagen_E06_A04_P2_TDS18_SOHC_TRX21 Volkswagen_E06_A06_DOHC_M6 Volkswagen_E06_A06_DOHC_TRX11 Volkswagen_E06_A06_DOHC_TRX21	VW_E06_A04_TDS18_DOHC_M6 VW_E06_A04_TDS18_DOHC_TRX22 VW_E06_A04_TDS24_DOHC_M6 VW_E06_A04_TDS24_DOHC_TRX22 VW_E06_A04_TDS18_P2_TRX21 VW_E06_A06_ATK2_DOHC_M6 VW_E06_A06_ATK2_DOHC_TRX22 VW_E06_A06_ATK2_TURBM_DOHC_TRX22
	Engines treated as 8 cylinders	Volkswagen_E08_A06_TDS18_DOHC_M6 Volkswagen_E08_A06_TDS18_DOHC_TRX21 Volkswagen_E08_A06_P2_TDS18_DOHC_TRX21 Volkswagen_E08_A08_DOHC_M6 Volkswagen_E08_A08_DOHC_TRX21 Volkswagen_E10_A08_TDS18_xOHV_TRX21 Volkswagen_E10_A08_TDS18_DOHC_TRX21 Volkswagen_E10_A10_DOHC_M6 Volkswagen_E10_A10_DOHC_TRX21 Volkswagen_E12_A12_DOHC_TRX21 Volkswagen_E14_A12_TDS18_DOHC_TRX21	VW_E08_A08_ATK2_DOHC_TRX22 VW_E08_A08_ATK2_TURBM_DOHC_M6 VW_E08_A08_ATK2_TURBM_DOHC_TRX22 VW_E08_A08_P2_TRX22 VW_E08_A06_TDS18_P2_TRX21
	Diesels	Volkswagen_E06_A04_DOHC_DSL_M6 Volkswagen_E06_A04_DOHC_DSL_TRX11 Volkswagen_E08_A06_DOHC_DSL_TRX21	VW_E06_A04_DSL_M6 VW_E06_A04_DSL_TRX22 VW_E08_A06_DSL_TRX22
	EV & PHEV	Volkswagen_E08_A06_REEV40_TDS18_TRX21 Volkswagen_E08_A08_REEV40_DOHC_TRX21 Volkswagen_E75	VW_REEV40_TRX21 VW_E08_A06_TDS18_REEV40_TRX21 VW_EV75 VW_EV100 VW_EV200
Volvo	Engines treated as 4 cylinders	None	None
	Engines treated as 6 cylinders	Volvo_E06_A04_TDS18_DOHC_TRX21 Volvo_E06_A06_DOHC_TRX11	Volvo_E06_A04_TDS18_DOHC_TRX22 Volvo_E06_A04_TDS24_DOHC_TRX22
	Engines treated as 8 cylinders	Volvo_E07_A05_TDS18_DOHC_TRX11 Volvo_E08_A06_TDS18_DOHC_TRX11	Volvo_E08_A08_DOHC_TRX22 Volvo_E08_A08_ATK2_DOHC_TRX22

	EV & PHEV	None	Volvo_EV200 (ZEV) Volvo_REEV40 (ZEV)

Notes: E=Effective cylinders; A=Actual cylinders; TDS=turbo/downsized; 18/24=bar; DOHC=dual overhead cam; SOHC=single overhead cam; OHV=overhead valve; TRX denotes the OMEGA transmission mapping, where TRX00 denotes less than 6 gears (not actually used in OMEGA, used here only for presentation; M=manual transmission; AKT2=Atkinson-2; TURBM=Miller cycle; P2=hybrid; REEV=plug-in hybrid electric vehicle; EV=battery electric vehicle; ZEV=zero emission program vehicle and denotes introduction into the fleet for ZEV program purposes only, where not shown it denotes OMEGA creation in addition to the ZEV program.

Toyota questions the application of electric power steering (EPS) to the LX570/Land Cruiser, claiming that it is inappropriate for off-road use. EPA has previously observed (for example, in the Draft TAR at p. 5-200) that EPS has been successfully implemented on all light duty vehicle classes (including trucks) with a standard 12V electrical system. Due in part to this observation, EPA has used the EPS code to denote either true EPS or electro-hydraulic power steering (EHPS) and tracks both as EPS in OMEGA. Importantly, the LPM considers the vehicle type in making the effectiveness determination for EPS (see the final TSD in support of the 2012 FRM at section 3.4.3.1) and uses the same cost and effectiveness values for EPS as it would for EHPS. While EPA disagrees with Toyota about EPS not being a viable technology for their trucks, the use of EHPS in such vehicles would not change the OMEGA results.

Toyota also questions why the car/truck mix has changed in the Proposed Determination relative to the Draft TAR. This change is the result of moving to the more recent AEO projections of future fleet mixes, not due to changes made independently by EPA.

Toyota also highlights differences between the Draft TAR and the Proposed Determination with respect to treatment of their RAV4 (see Table 3 of the Toyota comments). They express confusion over why the RAV4's cost in the Draft TAR was $1531 while in the Proposed Determination it was $1733, when only a transmission change appears to have been made (from TRX21 to TRX22). In response, there were more aspects to the changes than understood by Toyota, suggesting some misunderstanding of OMEGA. The costs shown in Toyota's table are costs of a package when applied to their vehicle. The costs are not necessarily the final costs for that vehicle. That said, there were minor differences in the way the RAV4 was characterized in the Draft TAR baseline and in the Proposed Determination baseline. In the Draft TAR, the baseline RAV4 was characterized as having 3.5 percent mass reduction and EPS. In the Proposed Determination the baseline RAV4 had no EPS (erroneously in this case as discussed in 2.7.1 of this document) and had no mass reduction. As a result, the baseline RAV4 had $243 (2014$) in technology. In the Proposed Determination, the RAV4 had $290 in technology (2015$). At 3.5 percent mass reduction, the costs for the technology are negative, hence the higher cost in the Proposed Determination, since a cost save associated with mass reduction is not included (this is partly offset by the presence of EPS in the Draft TAR while not in the Proposed Determination). For the package being added, the Draft TAR package had a cost of $1774 (2014$) while the Proposed Determination had a cost of $2023 (2015$) with that cost differential being due to the transmission difference along with the dollar-basis difference. The final increase in costs associated with adding these packages is $1531 (2014$) in the Draft TAR ($1744 minus $243) and $1733 (2015$) in the Proposed Determination ($2023 minus $290).

Toyota also expresses concerns regarding differences in results for their Sequoia and Land Cruiser, where the Proposed Determination showed higher costs and lower final CO_2 for those vehicles. Toyota does not express what their specific concerns are over the results. In the Proposed Determination, those vehicles are part of the same OMEGA-platform which is placed on the unibody mass reduction cost curve, making mass reduction more cost effective relative to the Draft TAR. As a result, OMEGA pushes the platform further on mass reduction as well as adding MHEV48V technology to some vehicles. These technologies became more cost effective relative to other possibilities for the platform allowing for more control on the platform in favor of reducing costs elsewhere. This outcome is reasonable especially in light of our interest in showing a compliance pathway rather than a prediction for each individual vehicle.

The Global Automakers also questioned why the technology penetration of the Atkinson 2 technology went down in the Proposed Determination. In response, it seems reasonable for it to have gone down given that a lower effectiveness value was applied to this technology (see Chapter 2.5.1 of this document) while maintaining equivalent costs relative to the Draft TAR. In combination with other changes, notably the movement of more vehicles to the unibody mass reduction cost curve, the result is reasonable.

With respect to comments regarding EPA's expectation that the MY2021 reference fleet would comply with MY2021 standards, both the Alliance and Toyota commented that compliance with the MY2021 standards were not a "given." Both commenters point to a recent study by their contractor, Novation Analytics, which projects that the MY2016 fleet will not comply with the MY2016 standards. As the final MY2016 sales data is not yet available, Novation Analytics was forced to rely on a number of alternative information sources including sales projection data from vehicle manufacturers and vehicle registration data from IHS-Markit, as well as their own projection of the application of credits. Without explicitly saying so, the commenters seem to be extrapolating this estimated MY2016 compliance condition onto MY2021, with the conclusion that the fleet will no longer be able to comply with future model year standards and that MY2016 is the beginning of the end of fleet compliance. EPA disagrees with this conclusion for several reasons. The estimated compliance situation provided by Novation Analytics is not based on final MY2016 sales data and credit usage. Depending on when the sales estimates were made, final data that has undergone the entire quality control process required for establishing fleet compliance can be significantly different. In addition, a single model year compliance situation does not reflect the long term compliance strategy for a single manufacturer or for the fleet. All manufacturers are managing their compliance with respect to their product plans and available credits. Individual manufacturer decisions to use banked credits in lieu of making product changes to meet a single model year's standards may reflect a legitimate short-term compliance strategy (for example, to use credits to better align with redesign schedules) but not be an indication of future model year compliance capability. In fact, as pointed out in Novation's MY2016 analysis, many vehicle manufacturers have over complied in the initial model years of the GHG program so it is reasonable to expect some level of under compliance in future model years. This is an example of one of the flexibilities inherent in the credit averaging, banking and trading provisions in the 2012 FRM.

The Alliance also commented that the phase-out of Flexible Fuel Vehicle (FFV) credits and the shift in sales from cars to trucks is negatively impacting the vehicle manufacturers' ability to comply with current and future standards. The Alliance further concludes that the difference between the projected CO_2 performance from the 2010 FRM vs. the actual CO_2 performance of the 2012 to 2016 MY fleet is the result of over-optimistic technology deployment rates and effectiveness. EPA does not agree with this conclusion or that the differences between the projected and actual performance are the result of technology penetrations and effectiveness. The projections provided by EPA in the 2010 FRM were based on a car/truck sales mix that has changed significantly since the FRM. Comparing the FRM projections to the actual fleet performance is inappropriate. This is best exemplified by the fleet target shown on slide 31 of the Novation Analytics study. On this slide, the fleet target established by Novation Analytics is 260 g/mile as compared to the projected target of 250 g/mile from the 2010 FRM. This change in target is mainly due to the shift in sales from passenger cars to trucks. A key point here is that the performance of today's fleet relative to a six-year old projection is irrelevant—the fleet changes and the targets change with it due to the footprint-based nature of the standards. The important point is that the fleet continues to improve along a trajectory consistent with the original intent of the national program – that being to cut in half the greenhouse gas emissions rate by 2025.

As for GM's comments regarding transmission technology penetration rates, this can be explained by the updated technology effectiveness values as discussed in Chapter 2.5.4 of this RTC document. The result of those changes was to move more vehicles to the TRX22 technology and away from the TRX21 technology. GM rightly points out that the TRX22 sensitivity shows higher costs than the central case illustrating the importance of this technology although not a reliance on it for feasibility. We also discuss comments relating to perceived volatility of results in Chapter 2.1 of this RTC document.

Chapter 3: Economic / Consumer / Other Factors

3.1 Consumer Response

Summary of Comments on the Draft TAR addressed in the Proposed Determination

Section B.1.2 of the Appendix to the Proposed Determination discussed the conundrum that private markets appear to have been slow to provide fuel-saving technologies with short payback periods, a phenomenon referred to as the energy paradox or the efficiency gap. The Appendix section includes an overview of the comments EPA received on this topic in the Draft TAR and EPA's responses to these comments.

Sections B.1.1 and B.1.3 of the Appendix to the Proposed Determination and Chapter 4.2 of the TSD discuss consumer response to vehicles subject to the standards, with a focus on vehicle sales. Sections B.1.1 and B.1.3 of the Appendix and Chapter 4.2.1 of the TSD include an overview of the comments EPA received on this topic in the Draft TAR and EPA's responses to these comments.

Some commenters argued that a number of market and behavioral failures have contributed to the existence of the energy efficiency gap. As EPA discussed in Appendix B.1.2 of the Proposed Determination and Chapter 6.3 of the Draft TAR, there are a number of hypotheses to explain the existence of the gap; there is relatively little research to test the hypotheses. The finding of a gap is demonstrated in the technical analysis of cost and effectiveness of the standards.

Many of the comments focused on the role of fuel economy in consumers' vehicle purchases, and what payback period for fuel-saving technologies consumers will consider. (What discount rate people use to evaluate fuel savings is another way of considering the same issue, how people trade off up-front costs and future savings over time). This value affects how people will respond to standards that increase up-front costs while providing fuel savings over the vehicles' lifetimes. Some commenters suggested that vehicle buyers take into account fuel savings over less than the lifetimes of their vehicles, perhaps as little as 2-3 years of fuel savings, when they make their purchase decisions. Consumers considering less than the lifetime of fuel savings in their purchases is often considered evidence of the efficiency gap. EPA in Appendix B.1.2 of the Proposed Determination and Chapter 6.3 of the Draft TAR reviewed the evidence on the role of fuel savings in consumer purchase decisions. There, EPA agreed with the National Academy of Sciences that there is not a definitive answer at present.[40] Some studies show that consumers undervalue fuel savings; others find no or little undervaluation; some find overvaluation.

The payback period that consumers use plays a key role in examining the effects of the standards on vehicle sales. Some comments requested that EPA conduct a quantitative assessment of the effects of the standards on vehicle sales. As EPA discussed in Section B.1.3.3 of the Appendix to the Proposed Determination, evidence suggests that models of consumer vehicle demand have not yet demonstrated their suitability for policy analysis, in part due to the large uncertainty over the role of fuel economy in consumers' vehicle purchase decisions. Nevertheless, as the Draft TAR presented in Chapter 6.2, the standards for MYs 2012-16 have

[40] National Research Council (2015). Cost, Effectiveness and Deployment of Fuel Economy Technologies for Light-Duty Vehicles. Washington, D.C.: The National Academies Press, pp. 9-16, 9-36. Docket EPA-HQ-OAR-2015-0827-0273.

not prevented vehicle sales from achieving record levels. The standards appear to play a far smaller role in vehicle sales than broader macroeconomic forces.

For future years, some comments expressed concern that the costs associated with the standards would be higher than EPA estimated in the Draft TAR, and that these higher costs would reduce vehicle sales. EPA does not agree with these cost estimates. As discussed in Chapter 4.2.1 of the TSD, some of the cost estimates from these commenters are not based on costs of the technologies expected to be used to meet the standards, but rather on outdated estimates of changing sales mix with fixed technologies, and therefore are not relevant to the standards. Other estimates are based on divergences from price patterns in a few selected overseas markets; as discussed in Appendix B.1.6.2 to the Proposed Determination, this approach does not provide a sound basis for estimating the effects of the standards on vehicle prices.

Some comments suggested that costs would be higher because more electrification of the fleet (both hybrid-electric vehicles and plug-in vehicles) is required than EPA has estimated. As discussed in Appendix C.1.1.3 to the Proposed Determination, EPA finds that the standards can be met almost fully with advanced gasoline technologies. For a small segment of the public, PEVs already are suitable for their purposes. As the technology of PEVs evolves, especially as range and fueling infrastructure expand, it is likely that a larger segment could find PEVs suitable.

Summary of Comments on the Proposed Determination

The comments on the Proposed Determination repeat many of these points.

Impact on sales

The Blue-Green Alliance, Center for Biological Diversity (CBD), Consumer Federation of America (CFA), Consumers Union (CU) Environmental Defense Fund (EDF), International Council for Clean Technology (ICCT), Michigan League of Conservation Voters, Natural Resources Defense Council (NRDC), Union of Concerned Scientists (UCS), Utah Physicians for a Healthy Environment, and the joint comments of 74 environmental groups argue that the standards provide significant net benefits to consumers. Some point to polls indicating the popularity of the standards across diverse populations. Various of them also point out that sales are high, the auto industry is profiting while the industry is over-complying with the standards, options for fuel-efficient vehicles have increased, and exports have increased.

Automakers express concerns about the effects of the standards in the MY2022-25 period, generally because they expect costs to be higher than EPA estimates, due to greater electrification than EPA considers necessary to meet the standards. Fiat Chrysler argues that its sales elasticity shows potential reductions in sales in the MY2022-2025 period. The Alliance argues that auto sales are inelastic, citing a report from the Center for Automotive Research (CAR) (MacAlinden et al. 2016). The Alliance, Global Automakers, National Automobile Dealers Association (NADA), and Fiat Chrysler argue that EPA should have done a quantitative vehicle sales analysis; CBD disagrees with the need for quantification. Fiat Chrysler suggests that EPA look at sales of “high efficiency” vehicles relative to other segments of the market; Global Automakers considers sales of electrified vehicles to be proxies for consumer acceptance of efficiency technologies. Ford and Toyota request that EPA include macroeconomic forecasting to develop its baseline and sales projections. CBD, NRDC, and UCS raise concerns about models of consumer preferences for vehicles. CBD and NRDC mention that the models are typically based on existing vehicles, not future vehicles with innovations; models based on existing vehicles will not produce good results. UCS points out that the lack of consensus on consumer willingness to pay for vehicle attributes arising from these models suggests that the use of these models for quantitative analysis is not appropriate. CBD argues that "consumer preference is not one of the factors set forth in the pertinent regulation that EPA must consider."

The Alliance, NADA, Fiat Chrysler, and Ford continue to cite MacAlinden et al. (2016). The Alliance says that EPA has not refuted it; NADA argues that, although it is not perfect, it is superior to EPA's analysis because it does provide quantitative estimates. The International Center for Clean Transportation (ICCT), and UCS support EPA's critique of the CAR Report. CAR defends its study (MacAlinden et al. 2016), arguing that:

- It did not base its costs on a 1991 study, but rather its cost assumptions of $2000 - $6000/vehicle "were used in place of a single, derived fuel efficiency scenario." It argues that its low value, $2,000, includes a retail price equivalent multiplier of 1.86; without that multiplier, the cost, $1075, is similar to EPA's estimated technology cost.
- It did not use discounting studies in its assessment of consumer payback periods because of the assumptions needed to convert them to payback periods.
- Its use of two very similar models that produce different results is due to different purposes for the models (one for revenues, one for consumer expenditures). They appear to contradict each other because one is in nominal dollars, while the other is in real dollars.
- If increased prices cause expenditures to decrease, then sales decrease, and employment decreases. The decrease in sales is a signal that consumers do not want the added content associated with the price increase, and thus employment decreases due to sales decreases account for "substitution effect" employment. In addition, new technologies substitute for existing technologies, rather than adding content.

The Alliance and Fiat Chrysler consider speculative EPA's statement that the impacts of the standards on vehicle sales are likely to be secondary to broader economy-wide impacts. This claim is based on the lack of quantification of sales and employment impacts.

Mercedes-Benz expresses concerns about the impacts to leasing and residual values due to the program. In particular, with most lease terms for 36 months, it is concerned that "the payback period of new technologies required will not be short enough to be attractive to these consumers."

Role of Fuel Economy in Consumer Vehicle Purchase Decisions and the Energy Paradox

Fiat Chrysler, the Institute for Energy Research (IER), and an assessment by the Defour Group provided by the Alliance (as an attachment to their comments) express skepticism of the existence of the energy paradox, noting that consumers may not undervalue fuel economy. Instead, according to IER and Toyota, consumer heterogeneity might explain what appears to be an efficiency gap, citing a paper by Bento et al.[41] Defour states that people might rationally wish to spend on attributes other than fuel-saving technologies, and that the standards require foregoing other vehicle attributes; indeed, it says EPA does not provide good evidence of consumer irrationality, and fuel economy labels should be sufficient to overcome that irrationality. It argues that OMB Circular A-4 requires demonstration of consumer irrationality.

On the other hand, CFA points to a large number of market imperfections. NRDC points out that manufacturer risk aversion may contribute to undersupply of fuel-saving technologies. CU asserts that automakers seem resistant to adding technologies that save consumers money; it argues that consumers prefer to spend more on vehicles than on fuel, and that "it is a disservice" not to provide consumers with cost-effective fuel-saving technology. UCS observes that manufacturers will under-supply fuel efficiency technologies if they assume that consumers require a 2-3 year payback period for costs when consumers may be willing to accept longer payback periods.

Global Automakers continues to argue that consumers consider only 2-3 years of fuel savings in their vehicle purchase decisions; the Center for Automotive Research (CAR) points out that EPA mentions this finding. In contrast, CBD, citing CU, supports a 5-year payback, although Toyota questions this finding. NADA seeks for EPA to conduct a meta-analysis of the willingness-to-pay for fuel economy, using Strategic Vision's results on how consumers rank fuel economy in their purchase decisions, and considers EPA's conclusions to be "seriously flawed" without using those data. Global Automakers and Toyota argue that EPA should use higher rates than 3 and 7 percent to discount fuel savings; Toyota recommends credit-card interest rates. UCS, on the other hand, says that estimates of the willingness to pay for fuel economy are highly varied, and admonishes against cherry-picking results. It notes that Toyota's credit card interest rate corresponds to a payback period of 5-6 years, greater than the assertion of 2-3 years.

Global Automakers argues that EPA did not rely on real-world data, but rather relied on academic studies that do "not provide definitive answers" in assessing consumer demand for fuel efficiency and electric-drive vehicles. NADA would like EPA to assist in influencing consumers to buy more efficient vehicles. Fiat Chrysler recommends that EPA compare sales of "high efficiency vehicles" relative to those in other segments.

Global Automakers disputes an EPA interpretation of a NADA finding discussed in the Proposed Determination. NADA found that 68 percent of consumers would pay $30 or less per month for a 17-mpg increase in fuel economy. EPA pointed out that, with a 5-year payback period at a 5 percent interest rate, $30/month is equivalent to $1,558 in up-front costs, which is less than the cost of the MY2022-2025 standards. Global Automakers points out that the fuel economy gain over the MY2022-2025 program is 5.1 mpg, not 17 mpg, as in NADA's scenario.

Role of Lower Gasoline Prices

The Alliance, Global Automakers, and GM say that EPA does not adequately consider how low fuel prices reduce the importance of fuel economy in consumer vehicle purchases, and

[41] Bento, Antonio, Shanjun Li, and Kevin Roth (2012). "Is there an energy paradox in fuel economy? A note on the role of consumer heterogeneity and sorting bias." Economics Letters 115: 44-48. An early version of this paper is docketed at EPA-HQ-OAR-2010-0799-11940.

reduce consumer acceptance of efficient vehicles. Ford and Toyota point to diminishing returns to increasing fuel economy. Ford argues that it needs to add other attributes to get people to buy more efficient vehicles. In addition, Ford argues that increased costs will shift the market to trucks, because the fuel economy gains are greater in that segment.

NADA points out that efficiency gains cannot be achieved if vehicles aren't sold, and argues that EPA should aim to maximize fleet turnover.

Payback Period Analysis

Fiat Chrysler argues that EPA's payback calculation used the prime interest rate; this interest rate, available to borrowers with strong credit ratings, is lower than that for subprime borrowers. Toyota says that the payback calculation "conflates the intended concern of vehicle affordability raised in the comments with a myopic view of payback."

Response to Comments on the Proposed Determination

Impact on Sales

As EPA discussed in the Sections B.1.1 and B.1.3 of the Appendix to the Proposed Determination and Chapter 4.2 of the TSD, and in Section I.A. of the Final Determination, the standards to date have not stopped the auto market from achieving record sales levels. We note here the argument from the Alliance and Fiat Chrysler, that EPA is speculating when it claims that the standards play a role secondary to broader macroeconomic conditions in determining sales. In the context of the last 5 years, this claim from the Alliance and Fiat Chrysler, that the standards play a significant role in sales and in broader macroeconomic conditions, suggests that the standards may have contributed significantly to the sales boom and economic growth. EPA does not have evidence for such a finding. We recognize that the Alliance and Fiat Chrysler instead seek to imply that, in the future, the standards will play a more significant role in sales. This argument is based on the premise that costs to meet the standards will be much higher than EPA has estimated. We continue to support our cost estimates, and therefore do not expect the effect on sales to be very large. The effects of the standards on vehicle prices are discussed further in Section 3.3, below.

The arguments for quantifying vehicle sales impacts seem to claim that even flawed quantification is better than no quantification. EPA does not agree that quantification is inherently superior to qualitative results; the discussion in Section 3.4, below, relating to quantification of employment impacts, applies here as well. As discussed in the Section B.1.2 of the Appendix to the Proposed Determination (and previously in the 2012 FRM, 77 Federal Register 62946-62950, and RIA Chapter 8.1), a key parameter in determining the effects of the standards on vehicle sales is the role of fuel economy in consumer vehicle purchases. As discussed there and below, and as the comments suggest, the research that has been done on the appropriate value has not reached anything approaching consensus. Without that key parameter, estimates of the effects of the standards on vehicle sales range from reductions, as CAR and others cite, to increases. EPA considers examination of consumer preference to provide useful information, even if it is not quantified.

The elasticity of vehicle demand (sales) with respect to price is another key parameter; it measures how sales respond to a change in price. In response to Fiat Chrysler, we note that the elasticity does not by itself determine whether sales will increase or decrease; the role of fuel economy in vehicle purchases—the share of future fuel savings that consumers take into account when buying vehicles--is needed for that directional indicator. If that share of fuel savings exceeds technology costs, then sales would be expected to increase. The elasticity determines the magnitude of the sales impact. We observe that the inelastic response—a smaller percent change in sales than percent change in price--argued by the Alliance suggests smaller sales impacts than an elastic response.

It is not obvious how to implement Fiat Chrysler's suggestion of comparing sales of "high efficiency" vehicles to sales of vehicles in other segments. The standards are intended to increase the efficiency of vehicles across the fleet, not just in limited segments. If Fiat Chrysler means that EPA should compare electrified vehicles to other vehicles (and as Global Automakers specifically indicates), EPA disagrees that this approach will produce valid insights. First, EPA projects that the standards can be met with very low levels of electrification. Second, these vehicles are often not directly comparable in other attributes to conventional vehicles.

Regarding the request for the use of macroeconomic forecasting for the baseline and sales projects, EPA notes that the reference fleet is based on macroeconomic projections from the EIA and IHS; the baseline is the actual data from MY2015 (see TSD Chapter 1). We agree with CBD that models of consumer demand for vehicles are typically based on existing or historic fleets and may not reflect consumer preferences for future vehicles.

Mercedes-Benz's concern about payback period for leased vehicles is based on an expectation that the first owner/leaser must pay for the full value of the technology in those three years. After the lease period ends, the vehicles are expected to be resold. The studies on the role of fuel economy in vehicle purchases, discussed in Appendix Section B.1.2 of the Proposed Determination, find that fuel economy continues to play a role in purchases in the used vehicle market. Thus, the full payback for new technologies need not be the responsibility of the first vehicle owner/leaser.

EPA continues to find the CAR Report not applicable to the standards, for the reasons stated in TSD Chapter 4.2.1 and Section B.1.3 of the Appendix to the Proposed Determination. In response to the points raised by CAR in its comments here, we respond:

- We continue to disagree with the cost estimates from CAR; regardless of their source, they are not based on an analysis of the costs of technologies sufficient to meet the standards. We also disagree that the cost estimate without the retail price equivalent multiplier, $1075, is similar to EPA's primary estimate of $875 (see Table ES-1 of the Proposed Determination), because EPA's estimate already includes use of indirect cost multipliers, which account for indirect costs related to production (which can be reflected in the retail price); thus, CAR's low estimate of $2000 is more than twice EPA's primary estimate, and reflects a significant element of double counting costs.

- In deciding which studies to consider in assessing the role of fuel economy in consumer purchase decisions, CAR decided not to use studies that estimate consumers' implicit discount rates. Discount rates are another way of estimating the role of fuel economy in consumer decisions; rather than considering fuel savings for only a few years (the payback period approach), the discount rate approach considers the lifetime of fuel savings, and estimates the weight (the discount factor) that consumers put on those future fuel savings. It is true that assumptions are needed to convert one approach into the other. Nevertheless, these studies (CAR itself cites 7), typically based on consumers' actual behavior, provide useful insights into consumer decision-making.[42] Studies of payback typically use stated-preference data, not revealed behavior.

- CAR's explanation of getting different results from similar models is that one is in nominal dollars, and the other is in real (constant) dollars, where the difference is inflation. However, inflation is just a multiplicative constant in these regressions; it should not by itself affect the relationship between expenditures (or revenues) and price. EPA still considers these models not to be of sufficient quality to estimate elasticities or to forecast revenues or expenditures.

- CAR's argument for excluding the substitution effect does not reflect the purpose of this effect. The substitution effect is that part of the increased cost of the standards that is due to labor inputs to production. (Indeed, the vehicle manufacturer comments emphasized the importance of the substitution effect. See e.g. the Alliance comments at p. 23). CAR's explanation instead is about the "output effect," which is the effect of changes in sales on employment, that EPA does not quantify. CAR further argues that the new technologies primarily substitute for other technologies. If that were strictly true, the standards would not impose additional costs other than materials. EPA finds that the fuel-saving technologies have added costs, and part of those increased costs is labor. This increase in labor is the substitution-effect employment; see Section B.2 of the Appendix to the Proposed Determination, where we estimated substitution-effect employment impacts to be between 1000 and 12,000 job-years in MY2025.

Role of Fuel Economy in Consumer Vehicle Purchase Decisions and the Energy Paradox

EPA continues to agree with the National Academy of Sciences that the role of fuel economy in consumer vehicle purchase decisions is unresolved. As EPA has previously pointed out (see Section B.1.2 of the Appendix to the Proposed Determination), the 2-3 year payback cited by Global Automakers is the low end of the possible scale; at the other end, as argued by Defour and IER, consumers may not undervalue fuel savings, and instead are acting rationally. A payback period of 2-3 years suggests substantial undervaluation and is thus potential evidence of the existence of the energy paradox. The use of alternative discount rates for fuel savings, as discussed above, is a proxy for different payback periods; higher discount rates than opportunity costs tend to be considered evidence of consumer myopia, and thus of the energy paradox. EPA continues to disagree with Toyota that credit-card rates are the opportunity cost for borrowing when auto loan rates are the relevant opportunity cost metric; vehicles are rarely purchased via credit cards. In comments on the Draft TAR, for instance, Fiat Chrysler cited evidence that almost 86 percent of vehicles are financed, which we assume does not include credit cards. We also note that several commenters endorse the use of survey data from Strategic Vision on the importance of fuel economy in consumer vehicle purchases; other commenters point to survey data, including that from Consumers Union (CU), showing widespread consumer support for

[42] CAR's list, in addition, is outdated and incomplete. For instance, it cites working paper versions of Allcott and Wozny from 2010, and Sallee et al. from 2011; they are both now published and discussed in the Draft TAR and the Proposed Determination (Docket EPA-HQ-OAR-2015-0827-0107 and EPA-HQ-OAR-2015-0827-0120); and it omits Busse et al. 2013 (Docket EPA-HQ-OAR-2015-0827-0110).

strong fuel economy standards; and some argue against the use of showing general public attitudes toward fuel economy, as not reflecting actual consumer behavior. We consider all these sources to inform, but not be decisive for, the role of fuel economy in consumer vehicle purchases.

As noted, Defour and IER argue that consumers are rationally choosing to spend on vehicle attributes other than fuel economy. Fuel economy is unusual in being the only attribute of a vehicle that has the potential to pay for itself in cash savings. In addition, as discussed in TSD Chapter 4.1 and Section B.1.4 of the Appendix to the Proposed Determination (and in Section 3.2 below), fuel economy and other vehicle attributes are not mutually exclusive, so there is no necessary tradeoff between fuel economy and other vehicle attributes. Purchasing both comes at a cost; as noted, though, the fuel-saving technologies can pay for themselves. Section B.1.6.3 of the Appendix to the Proposed Determination and TSD Chapter 4.3.3 further discuss EPA's assessment of the effects of the standards on access to the credit market. As discussed there, it is possible that there may be an effect, but the limits on access to credit do not appear absolute.

Defour argues that EPA does not provide good evidence of consumer irrationality, and claims that such evidence is required by OMB Circular A-4. EPA notes, first, that it is not issuing the standards to "correct" for consumer irrationality; rather, it is issuing the standards to reduce vehicle GHG emissions. Second, EPA's assessment of the energy paradox is based in its technology assessment: we find that fuel savings outweigh technology costs, and, as discussed in Chapter 4.2 of the TSD and Appendix Section B.1.5 of the Proposed Determination, we have not found evidence of "hidden costs" of the technologies. Thus, the finding of the gap does not rely on findings about consumer behavior. Third, EPA discussed extensively (see Proposed Determination Appendix Section B.1.2) the possible reasons for the efficiency gap, including the possibility of consumer heterogeneity (see Proposed Determination Appendix p. A-29: "Because consumers differ in how much they drive, they may already sort themselves into vehicles with different, but individually appropriate, levels of fuel economy in ways that an analysis based on an average driver does not identify"). Because EPA was summarizing previous discussions, it did not cite all the pertinent literature, such as Bento et al., but it has previously considered that and many other papers. Finally, as discussed in that section, EPA also notes the possibility of producer-side factors as sources of the efficiency gap, such as strategic decisions over which attributes to offer in which vehicle segments. NRDC, CFA, and CU point to potential producer-side explanations. The commenters are correct that EPA has not made definitive findings on the source of the efficiency gap; nevertheless, the technology assessment is the basis for the observation that there continue to be technologies for which the expected present value of fuel savings exceeds estimated technology costs. Finally, OMB Circular A-4 does not require a finding of consumer irrationality; instead, it provides guidance and asks agencies to "examine and discuss why market forces would not accomplish these gains in the absence of regulation."[43] As noted, EPA has discussed extensively why these gains might not happen in the absence of the standards.

Global Automaker's concern that EPA relied on academic studies rather than "real-world data" is puzzling, because academic studies are commonly based on real-world data. It seems to be requesting that EPA instead look at slow sales of electrified vehicles as evidence for

[43] Office of Management and Budget (2003). "Circular A-4." https://www.whitehouse.gov/omb/circulars_a004_a-4/, Docket EPA-HQ-OAR-2015-0827-0803.

consumers not being interested in fuel-saving technologies. EPA's analysis suggests that only low levels of electrification are necessary to meet the standards. EPA further discussed consumer acceptance issues related to electrified vehicles in Appendix Section B.1.5.2 of the Proposed Determination and Section 3.2 below.

Regarding the NADA finding that most consumers would pay no more than $30/month for a 17 mpg increase in fuel economy, Global Automakers is correct to point out that the 17 mpg increase is not the projection for the MY2022-25 standards, but is instead approximately the increase expected from MY2016 to MY2025. In Table 12.44 of the Draft Technical Assessment Report, EPA estimates that the cost of going from MY2016 standards to MY2025 standards is $1,287. Five years of $30/month at a 5 percent discount rate is $1,558, which exceeds that value. EPA's primary point here is that NADA's estimate of $30/month, even if only for part of the population, suggests a significant willingness to pay for additional fuel-saving technology.

Role of Lower Gasoline Prices

EPA does not agree that we have not adequately considered the role of lower fuel prices. EPA's analysis was done using AEO estimates that reflected a lower fuel price scenario, and included sensitivity analyses for prices below the expected (reference) values. In addition, the fuel savings calculations are done by estimating volumes of fuel saved, not miles per gallon. We agree that there are diminishing returns to increasing mpg, but fuel savings increase with gallons saved. Though Toyota considers diminishing returns to be especially an issue for low-priced vehicles, calculating fuel savings rather than mpg increases avoids this concern for any segment.

We agree with NADA that efficiency gains will increase as more new vehicles penetrate the market. As discussed above, we have not made a prediction on the effects of the standards on vehicle sales. As discussed above, though, we do not consider the effects of the standards on sales to be as negative as the CAR Report implies.

Payback Period Analysis

EPA's calculation of the returns for those borrowing on credit reflect the average rate, 4.25 percent, at the time of the calculation (see Proposed Determination Appendix Section C.2.4). We recognize that some will get lower rates, and some will get better rates. The payback period analysis nevertheless indicates that fuel savings will recover technology costs in approximately 5-6 years (see Proposed Determination Appendix Section C.2.4). We do not understand the intent behind Toyota's statement of the conflation of affordability and "a myopic view of payback." Toyota does not provide additional explanation of this comment.

3.2 Consumer Impacts of New Technologies

Summary of Comments on the Draft TAR addressed in the Proposed Determination

Section III.A. of the Proposed Determination, Sections B.1.4 and B.1.5 of the Appendix to the Proposed Determination, and Chapters 4.1 and 4.2.2 of the TSD discussed EPA's assessment of the effects of greenhouse gas (GHG)-reducing technologies on other vehicle attributes. The Appendix sections include an overview of the comments EPA received on this topic in the Draft TAR and EPA's responses to these comments.

Some comments suggested that other vehicle attributes, especially vehicle power or size, might have increased in the absence of the standards, and requested that EPA develop a reference fleet based on larger and more powerful vehicles. Other comments suggested that EPA base its reference fleet on MY2010 vehicles, because any improvements in other vehicle attributes are due to automakers' choices not to use technological progress for reduced GHG emissions. Yet other comments pointed out that some of the GHG-reducing technologies provide ancillary benefits to other vehicle attributes, such as lightweighting providing better handling and performance. As discussed in the Proposed Determination Appendix Section B.1.4, EPA has updated the reference fleet to MY2015, to use the most recent final data, and maintains other vehicle attributes at their MY2015 levels. Because, as many comments pointed out, the standards appear to be contributing to major innovations, the standards may provide significant ancillary benefits as well as potential opportunity costs (although, as noted in Chapter 2.2.5 of this Response to Comments, the EPA analysis holds performance constant; i.e., the analysis holds acceleration constant (that is, includes costs to preserve acceleration) as a proxy for standards which preserve all performance attributes). In addition, as some comments indicated, it is not clear that consumer demand for additional power is large; and some innovations, such as improved infotainment systems, are not directly related to GHG emissions. In light of these issues, EPA maintained the static baseline in its modeling.

Some comments asked questions about EPA's analysis of professional auto reviews as a source of insight into consumer response to fuel-saving technologies. As discussed in Section B.1.5.1.2 of the Appendix to the Proposed Determination, EPA considers these analyses to provide useful insights into potential "hidden costs" of the new technologies. As documented in that section and in TSD Chapter 4.2.2, the studies found more positive associations with the existence of the technologies than negative associations. The evidence suggests that it is possible to implement these technologies well, and that automakers may improve their implementation over time.

Other comments expressed concern that vehicle buyers will not accept the higher costs associated with high levels of vehicle electrification. As discussed in the Proposed Determination Section III.A and the Appendix B.1.1, with the very low proportion of PEVs projected to be needed for compliance, EPA expects that compliance will mostly depend on advanced gasoline technology vehicles. Moreover, as discussed in Chapters 2.2.4.4.5 and 2.2.4.4.6 of the TSD, the market for electrified vehicles is evolving rapidly. As discussed in Section B.1.5.2 of the Appendix to the Proposed Determination, widespread consumer acceptance of PEVs may depend, not only on technological advances, but also on the feedback loop associated with other consumers purchasing PEVs.

Summary of Comments on the Proposed Determination

Potential Opportunity Costs of the Standards

The Defour Group (in an attachment to comments from the Alliance), Ford, Global Automakers, the Institute for Energy Research (IER), and Toyota express concerns that EPA ignores opportunity costs, because they claim the standards deny people the opportunity to buy vehicles with other attributes that they prefer to fuel savings, or because other attributes might be adversely affected. Global Automakers argues that the analysis of auto reviews conducted by EPA does not reflect consumer responses, nor does it reflect all technologies that will be used to meet the standards. The Natural Resources Defense Council, in contrast, considers EPA's analyses to be a fair assessment of the new technologies. IER points specifically to two studies (Whitefoot et al. (2011) and Klier and Linn (2016)) suggesting that consumers will be adversely affected.[44] The Union of Concerned Scientists (UCS) points out that Whitefoot et al. note consumer surplus gains, and that the Klier and Linn paper finds that fuel savings exceed the opportunity costs of performance. An anonymous commenter expresses concern that the standards are forcing people into larger vehicles and eliminating manual transmissions.

The Blue-Green Alliance (BGA), Business for Innovative Climate and Energy Policy (BICEP), Center for Biological Diversity (CBD), Consumer Federation of America, the Michigan League of Conservation Voters, and a joint letter from 74 environmental groups, in contrast, point to the tremendous innovations stimulated by the standards that drive down costs. BICEP, the Environmental Defense Fund (EDF), International Council for Clean Technology (ICCT), UCS, and Woodward argue that this innovation increases the competitiveness of the U.S. auto industry in the world economy. BGA, BICEP, ICCT, and UAW point out that the standards provide certainty necessary for the large investments being used to meet the standards; indeed, ICCT points to the uncertainty, and hence reduced investment, that would arise if the Determination is not finalized. In addition, BGA observes that research on electric vehicles for components such as start-stop and regenerative braking complements technology for conventional vehicles.

Consumer Acceptance of Electrified Vehicles

Ford, Global Automakers, Mercedes-Benz, Nissan, Subaru, and Toyota express concerns about consumer acceptance of electric-drive vehicles, and the potential need for cross-subsidization or government incentives to achieve the standards, based on its disagreement with EPA over the level of electrification needed to achieve the standards. Global Automakers observes, e.g., that 75 percent of HEV or PEV owners who replaced those vehicles in 2016 chose gasoline vehicles. The High Octane-Low Carbon Fuel Alliance argues that people prefer liquid fuel-powered cars. On the other hand, the California Air Resources Board (CARB), Faraday Future, the Center for Biological Diversity (CBD), and UCS argue that consumer acceptance for electrified vehicles is growing. UCS points to the advances in electric vehicle technology, such as longer range and lower costs. CARB points out that factors beyond fuel prices, including awareness of electrified vehicles, interest in driving, and using the latest technology, influence purchase of electrified vehicles; it points to survey data showing owner satisfaction with PEVs and intent to purchase another in the future. Toyota argues that more efficient conventional vehicles do not in fact have fuel economy comparable to hybrids, noting that the most efficient mid-sized gasoline car gets 36 mpg (combined city and highway), while the hybrid Prius gets 56 mpg combined.

[44] Whitefoot, Kate, Meredith Fowlie, and Steven Skerlos (2011). “Product Design Responses to Industrial Policy: Evaluating Fuel Economy Standards Using an Engineering Model of Endogenous Product Design.” Energy Institute at Haas Working Paper No. 214, Docket EPA-HQ-OAR-2010-0799-11895; Klier, Thomas, and Joshua Linn (2016). “(2016). “The Effect of Vehicle Fuel Economy Standards on Technology Adoption.” *Journal of Public Economics* 133: 41-63, Docket EPA-HQ-OAR-2015-0827-0142.

Response to Comments on the Proposed Determination

Potential Opportunity Costs of the Standards

As discussed in the Summary of Comments on the Draft TAR Addressed in the Proposed Determination above, EPA has extensive discussion and analysis of the potential opportunity costs of the standards in Section III.A. of the Proposed Determination, Sections B.1.4 and B.1.5 of the Appendix to the Proposed Determination, and Chapters 4.1 and 4.2.2 of the TSD. In those, EPA has not found systematic evidence of tradeoffs between fuel economy and other vehicle attributes, including performance. EPA agrees with various commenters that the standards have stimulated significant innovation; we argue that the innovation stimulated by the standards allows the possibility—in some cases the reality (e.g., the Ford F-150)—of getting improvements in both fuel economy and other vehicle attributes. EPA agrees with Global Automakers that its analysis of auto reviews does not measure consumer response. Nevertheless, we consider professional auto reviewers to be able and expected to identify any significant problems if they are observed.

IER cites an outdated version of Whitefoot et al.; the most recent version, from 2013, produces much lower estimates of consumer impacts.[45] UCS's finding of consumer surplus is likely to arise because Whitefoot et al. (2011) considered several scenarios; consumer surplus increased in some, and decreased in others. The 2013 version presents fewer scenarios and shows some losses in each. We note that Whitefoot et al. use old (2008) cost data, and expected that automakers could only comply with the standards by decreasing acceleration; as discussed in Chapter 3.1.5 of the Draft TAR, horsepower has instead increased. For that reason, we do not rely on this paper's results. IER cited one paragraph of EPA's assessment of Klier and Linn (2016), claiming it is "hardly enough to dispose of the serious objections" of this and similar studies. EPA's assessment of that and similar studies, in Chapter 4.1.3.1 of the Draft TAR, Appendix Section B.1.4 of the Proposed Determination, and Chapter 4.1.2 of the TSD, are much more detailed than the one (summary) paragraph referred to in IER's comments. In essence, while EPA does not dismiss the potential concerns of tradeoffs between fuel economy and other vehicle attributes, neither does it find that these concerns have to date actually occurred, except via the predicted pathway of costs of achieving the standards. As discussed in those sections of the Draft TAR and Proposed Determination, EPA expects that innovation related to other vehicle attributes will continue in the presence of these standards, and there may as a result be improvements in some other vehicle attributes during this time independent of the standards.

Regarding the anonymous commenter's concerns, EPA has not observed a lack of small vehicles. Although the average vehicle has increased slightly in size, small vehicles are still produced and sold; fueleconomy.gov, for instance, lists 104 subcompact cars in MY2016.[46] The declining market share of manual transmissions follows a historic trend; it unlikely to be due to increasingly stringent emissions standards, and instead is more likely the result of changing consumer preferences and manufacturer decisions about which models to offer with a manual

[45] Whitefoot, Kate, Meredith Fowlie, and Steven Skerlos (2013). "Compliance by Design: Industry Response to Energy Efficiency Standards." https://nature.berkeley.edu/~fowlie/whitefoot_fowlie_skerlos_submit.pdf , accessed 12/30/2016.

[46] Fuel Economy Guide 2016 Datafile, http://fueleconomy.gov/feg/download.shtml , accessed 01/09/2017.

transmission given the relatively low market demand. The same database lists 201 vehicles offered with manual transmissions.

We agree with various commenters that the standards not only stimulate innovation, but also that innovation contributes to the competitiveness of the U.S. auto industry in a world where many countries seek to reduce vehicle GHG emissions. ICCT, for instance, provides a chart showing existing and future standards becoming more stringent for a number of countries. We also agree that finalizing the Determination will provide certainty that will promote more investment in fuel-saving technologies.

Consumer Acceptance of Electrified Vehicles

EPA continues to rely on its analysis of the technology cost and effectiveness of vehicles, which indicates that the standards can be met with very low levels of electrification. Automakers are able to choose their own compliance paths, including increased use of electrification, and may use the flexibilities under the standards to bank or trade some of the credits associated with that choice. Those flexibilities are expected to reduce the costs of electrified vehicles.

Toyota observes that a 36-mpg midsize conventional gasoline car does not approach the efficiency of the hybrid Prius, at 56 mpg. The Prius is not the only midsize hybrid, though. The 2016 Toyota Camry Hybrid, depending on trim, gets 40-41 mpg, while the Kia Optima Hybrid gets 37-38 mpg.[47] The advantages of these HEVs over high-efficiency conventional midsize cars is obviously much smaller than the advantages of the Prius relative to these vehicles, and may help to explain why HEV sales are not very high.

Section B.1.5.2 of the Appendix to the Proposed Determination assessed factors relevant for consumer acceptance of PEVs. We continue to expect consumer acceptance to be sufficient for the levels of electrification that EPA projects. We agree with various commenters that increased marketing and incentives for electrified vehicles will aid in their adoption. We also agree with various automakers that there are limits to their abilities to cross-subsidize vehicle prices while still remaining profitable; given the longstanding differences in the profitability of different vehicles, though, those limits are unlikely to be zero. While Global Automakers observes that many HEV and PEV owners replaced their vehicles with gasoline vehicles, Ford, in a recent press release, observes that 92 percent of Ford EV owners expect to purchase another EV as their next vehicle, and 87 percent of PHEV owners want another PHEV for their next vehicle.[48] Thus, for the low levels of electrification projected for achievement of the standards, EPA does not foresee significant obstacles to consumer acceptance of electrified vehicles.

3.3 Affordability

Summary of Comments on the Draft TAR addressed in the Proposed Determination

Section III.A. of the Proposed Determination, Section B.1.6 of the Appendix to the Proposed Determination, and TSD Chapter 4.3 discussed EPA's assessment of the effects of the standards

[47] Fuel Economy Guide 2016 Datafile, http://fueleconomy.gov/feg/download.shtml , accessed 01/09/2017.

[48] Ford News (January 2017). "Ford Adding Electrified F-150, Mustang, Transit by 2020 in Major EV Push; Expanded U.S. Plant to Add 700 Jobs to Make EVs, Autonomous Cars." https://media.ford.com/content/fordmedia-mobile/fna/us/en/news/2017/01/03/ford-adding-electrified-f-150-mustang-transit-by-2020.html , accessed 01/04/2017.

on affordability. These sections include an overview of the comments EPA received on this topic in the Draft TAR and EPA's responses to these comments.

As discussed in Appendix Section B.1.6.1, some comments discussed whether the standards have a more significant impact on upper-income or lower-income households (the progressivity of the standards). There does not appear to be agreement in the cited studies. Other comments in this section argued that the standards will make lower-income households better off, because they spend more on fuel than they do on vehicles. Comments discussed in Appendix Section B.1.6.2 argued that prices of vehicles have been increasing; as EPA discussed there, when adjusted for inflation, prices have not been increasing; and the trends do not account for changes in sales mix, which in itself can increase average prices. See Chapter 3.1 above. Some comments in the Proposed Determination Appendix B.1.6.2 and B.1.6.3 expressed concern that access to credit and other indicators of vehicle affordability will be adversely affected as macroeconomic conditions, such as loan rates, change. EPA agreed that vehicle affordability will be affected by macroeconomic conditions, but the standards are likely to have at most a small role in any of those changes.

<u>Summary of Comments on the Proposed Determination</u>

Progressivity/regressivity of the standards

Since the Proposed Determination was issued, two working papers, cited by Defour Group (as an attachment to comments from the Alliance of Automobile Manufacturers), have asked whether the vehicle GHG standards provide proportionately more benefits to lower-income households (that is, they are progressive) or to higher-income households (regressive) than a gasoline tax. Both Levinson[49] and Davis and Knittel[50] examine this question by considering fuel economy/greenhouse gas standards as a tax on inefficient vehicles (those below their target efficiencies) and a subsidy on efficient ones (those above their target efficiencies). Defour Group further argues, citing Levinson, that the footprint-based standard is more regressive than a flat standard. Because low-income households disproportionately buy used vehicles, and because larger vehicles tend to survive longer than smaller used vehicles, Defour Group argues that the standards will lead to lower-income households having more powerful and less efficient vehicles.

The American Council for an Energy-Efficient Economy (ACEEE), Consumer Federation of America (CFA), Consumers Union, and the Center for Biological Diversity (CBD), in contrast, say that low-income households spend more on fuel than on vehicles, and that that low-income households will benefit more than average, both financially and in terms of health benefits. ACEEE points out that Davis and Knittel did not consider fuel savings in their calculation; if they had, the standards would be progressive. It also observes that Davis and Knittel did not account for innovation, which would be expected to decrease the costs of meeting the standards over time. CU points out that lower-income households benefit from the depreciated prices of used vehicles. The Environmental Defense Fund argues that used-vehicle buyers will get more

[49] Levinson, Arik (December 2016). "Energy Efficiency Standards Are More Regressive than Energy Taxes: Theory and Evidence." NBER Working Paper 22956, http://www.nber.org/papers/w22956.

[50] Davis, Lucas W., and Christopher R. Knittel (December 2016). "Are Fuel Economy Standards Regressive?" NBER Working Paper 22925, http://www.nber.org/papers/w22925.

diverse and more efficient choices, because the standards lead to improvements in fuel economy across the fleet.

Vehicle price changes

Since the Proposed Determination was issued, some new analyses raise questions about trends in vehicle prices.

Baum and Luria[51] as well as the Union of Concerned Scientists (UCS) and Consumers Union argue that increases in average vehicle prices are due to: higher market share for trucks, which are more expensive than cars; a stronger economy that supports higher prices; more content, beyond emissions and safety requirements, being added to vehicles; and the high income of those who buy new vehicles. D. Simmons, Furth of the Heritage Foundation,[52] and the Institute for Energy Research (IER, citing Heritage Foundation's assessments) argue that EPA's assessment of price trends is incorrect. First, Furth argues that EPA's interpretation of the price trend is incorrect. EPA's understanding was that this price index did not hold sales mix constant. If so, then even if vehicle prices are constant, average vehicle prices would increase if people are buying more expensive vehicles (as Baum and Luria argue). Furth instead states his belief that the price index holds sales mix constant. IER proposes two interpretations of the price trends since the recession: one, that the increase in vehicle prices was due to higher standards rather than improvements in vehicle quality (its preferred interpretation); alternatively, it asserts that EPA's interpretation is that people have "wanted to splurge on getting fancier models." Ford states that "content-equivalent real vehicle prices have been flat in recent years during a period of industry growth and declined during the pre-recession years" reflecting consumer expectations for content-equivalent vehicles. With expectations of reduced real disposable income growth in coming years, Ford is concerned that price increases will be difficult to support in the future.

UCS disagrees with Furth, arguing that the Heritage Foundation study[53] does not account for mix shift and for improvements in other vehicle attributes. The American Council for an Energy-Efficient Economy (ACEEE) presents price data indicating that prices of cars have dropped in real terms, while prices of light trucks have increased slightly; it finds that, if the fleet mix had stayed at 2009 levels, average expenditures would be $1331 lower than they are.

Fiat Chrysler states that EPA has not properly considered effects on the used car market, including the potential for the "jalopy effect," where higher prices for new vehicles lead people to hold onto used vehicles longer.

[51] Baum, Alan, and Dan Luria (December 2016). "Analyst Brief: Affordability of Vehicles Under the Current National Program in 2022-2025 for Detroit Three Automakers." https://www.ceres.org/files/analyst-brief-affordability-of-vehicles-under-the-current-national-program-in-2022-2025-for-detroit-three-automakers/at_download/file , accessed 12/28/2016.

[52] Furth, Salim (December 2016). "Issue Brief: Regulation Continues to Increase Car Prices." http://www.heritage.org/research/reports/2016/12/regulation-continues-to-increase-car-prices , accessed 12/28/2016.

[53] Furth, Salim, and David W. Kreutzer (2016). "Fuel Economy Standards are a Costly Mistake." The Heritage Foundation Backgrounder. http://www.heritage.org/research/reports/2016/03/fuel-economy-standards-are-a-costly-mistake, downloaded 5/20/2016.

Effects on Access to Transportation

Defour Group (in an attachment to comments from the Alliance of Automobile Manufacturers) argues that lower-income households especially need access to transportation, arguing that it is irrelevant whether there is a commonly accepted definition of access. It cites studies from 2003 emphasizing the role of personal transportation—vehicle ownership—to lower-income households.

Access to Credit

Global Automakers and Toyota point out the increasing average length of loans on new vehicles as a way for consumers to reduce their monthly loan payments, and considers EPA's analysis of related issues inadequate. NADA argues that lenders do not take potential fuel savings or reduced operating costs into account for loans. IER points out that EPA did not cite a 2012 study[54] on credit-constrained consumers; Ford criticizes EPA for not estimating how many people would not be able to get financing due to the standards.

Response to Comments on the Proposed Determination

Progressivity/regressivity of the standards

EPA agrees with ACEEE that both Levinson (2016) and Davis and Knittel (2016) look only at the implicit tax/subsidy on vehicles due to the standards. They do not allow for the possibility that the standards lead to fuel savings that exceed technology costs. As Levinson's paper says, "if the regulation makes consumers better off even ignoring the environmental benefits, then the distributional comparison with a gasoline or energy tax becomes moot" (p. 6). As shown in Table ES-4 of the Final Determination, EPA expects the fuel savings to exceed the technology and maintenance costs by $56 billion (3 percent discount rate; $26 billion at 7 percent), before consideration of the environmental benefits. EPA notes that the Levinson and Davis and Knittel papers focus on comparing the progressivity of fuel taxes to standards. Because EPA does not have statutory authority to tax gasoline, the relative merits of a gasoline tax are not relevant to EPA's determination on the appropriateness of the MY2022-2025 standards. In addition, Levinson's assessment of the footprint-based standard compared to the flat standard, cited by DeFour, is based on a stylized model where all vehicles are alike. As EPA previously pointed out in Appendix Section B.1.6.1 of the Proposed Determination, vehicle size may play a role in consumer welfare from the standard; the reduced incentives to downsize vehicles under the footprint standard may be an important feature that Levinson (cited by DeFour) has not incorporated into his model. In comments on the Draft TAR, Greene and Welch presented a paper that argued, not only that the standards are progressive, but that all income groups benefit from the standards. EPA expects that the gains to consumers from the net fuel savings will be widespread, even if it is not yet definitive which income groups benefit more. For these reasons, EPA continues to find that the evidence on the progressivity or regressivity of the standards is inconclusive. EPA expects that the gains to consumers from the net fuel savings will be widespread, even if it is not yet definitive which income groups benefit more.

[54] Wagner, D., P. Nusinovich, and E. Plaza-Jennings, National Automobile Dealers Association (February 13, 2012). "The Effect of Proposed MY 2017-2025 Corporate Average Fuel Economy (CAFE) Standards on the New Vehicle Market Population." Docket EPA-HQ-OAR-2010-0799-9575.

Vehicle price changes

We agree with Baum and Luria and others that the factors they cite might all contribute to higher vehicle prices. As discussed in the Proposed Determination Appendix Section B.1.6.2 and TSD Chapter 4.3.3.3, EPA found that prices in recent years, adjusted for quality and inflation, have been flat, not increasing. Because this price series adjusts for changes in content (i.e., quality), the flat trend does not contradict Baum and Luria's comment on increasing prices, which is based in part on added content. The International Energy Agency uses cross-country comparisons to conclude similarly that "average vehicle price is not strongly driven by fuel economy parameters, but rather by other attributes" (p. 39).[55] It finds that the major factors affecting vehicle price are vehicle segmentation and the market share of premium brands, not fuel economy.

The memo to the docket "Review of Heritage Foundation analyses, 'Fuel Economy Standards are a Costly Mistake' by Furth and Kreutzer, and 'Issue Brief: Regulation Continues to Increase Car Prices' by Furth" provides a more detailed assessment of these two analyses from the Heritage Foundation.[56] We continue to disagree with the Furth and Kreutzer argument that the standards have increased prices relative to counterfactual price trends, because we do not find that the price trends that Furth and Kreutzer cite meet the statistical criteria for representing what could have been expected to happen in the absence of the standards: closely matching price trends before the shock, and being expected to respond to common price shocks in the same way.[57] We do not find that the price trends cited for comparison—furnishings and durable household equipment, or vehicle prices in the U.K. or Australia—meet these criteria.

As we note, Furth does not provide citations to document his claim that the price indices do account for sales mix. EPA has confirmed with both the Bureau of Labor Statistics (BLS) and the Bureau of Economic Analysis (BEA) that changes in sales mix do in fact affect their price indices. For instance, documentation of BLS's sampling methodology[58] in the section of Selection Procedures within Outlets (p. 15) states, "The probabilities of selection are proportional to the sales of the items included in each group." In other words, if consumers are buying more expensive vehicles, the probability for being selected as a sample for Consumer Price Index would be higher for expensive vehicles. We note that Ford observes flat content-equivalent prices in recent years. In that case, addition of content—added either due to the standards or for other reasons—may contribute to the unobserved price increases cited.

EPA, similar to ACEEE, conducted an exercise to look at how changing market shares would affect average vehicle prices. This exercise, documented in the memo cited above, used sales and

[55] International Energy Agency (2017). "International Comparison of Light-Duty Vehicle Fuel Economy 2005-2015: Ten years of fuel economy benchmarking." http://www.globalfueleconomy.org/media/418761/wp15-ldv-comparison.pdf , accessed 01/11/2017.

[56] Assessment and Standards Division, Office of Transportation and Air Quality, U.S. EPA (December 2016). "Review of Heritage Foundation analyses, 'Fuel Economy Standards are a Costly Mistake' by Furth and Kreutzer, and 'Issue Brief: Regulation Continues to Increase Car Prices' by Furth." Docket EPA-HQ-OAR-2015-0827.

[57] Abadie, Alberto (2005). "Semiparametric Difference-in-Differences Estimators." Review of Economic Studies 72(1):1-19; Dimick, Justin B. and Andrew M. Ryan (2014). "Methods for Evaluating Changes in Health Care Policy: The Difference-in-Differences Approach." JAMA 312(22): 2401-2402.

[58] U.S. Department of Labor, Bureau of Labor Statistics. "Chapter 17. The Consumer Price Index (Updated 06/2015)." https://www.bls.gov/opub/hom/pdf/homch17.pdf , accessed 1/5/2017.

price data from model years (MYs) 2010 and 2015 to examine the effects of sales mix (at the class level) on vehicle prices between these years. Similar to ACEEE's findings, EPA found that, if the prices for MY2015 are used with the sales mix in MY2010, then average vehicle price would be about $1000 lower than the actual average price, just because of the different sales mix. Similarly, the sales mix in MY2015 at MY2010 prices would have an average price over $1000 more expensive than the actual average price. (All values are in 2015$). In other words, with vehicle prices held constant (at either 2010 or 2015 values), the sales mix is a more expensive one in MY2015 than in MY2010. Thus, changes in sales mix can contribute to average price increases. We note that this exercise does not account for changes in vehicle quality during that time; as a result, we cannot determine whether the increase in price for a constant sales mix is due to changes in vehicle content added due to the standards or for other reasons. We thus disagree with IER that the full increase in vehicle prices in recent years is due to the standards; instead, based on these analyses, we find that the increase in vehicle prices is due in part to people buying more expensive vehicles.

As EPA discussed in Appendix Section B.1.6.2 of the Proposed Determination, EPA expects (and has observed) that used vehicle prices respond fairly closely to changes in the new vehicle market. The "jalopy effect" might happen if the standards lead to decreased new vehicle sales, which would lead to people buying used vehicles, or holding onto used vehicles longer. Because EPA has not projected the effects of the standards on new vehicle sales, it does not conclude whether the standards might lead to higher or lower used vehicle prices.

Effects on Access to Transportation

EPA disagrees with the Defour Group that it is possible to evaluate trends in access to transportation in the absence of a way to evaluate or define access to transportation. The market for mobility services is changing rapidly, with increased urbanization, new opportunities for ride-sharing, changing interest in demographic groups in vehicle ownership, and the possibility in the near future that owning a vehicle may not be a prerequisite to quality transportation services. Thus, access to transportation for many does not now require a personal vehicle, and changes in the definitions of access to mobility are likely to continue.

Access to Credit

Issues related to access to credit depend heavily on changes in vehicle prices. As discussed above, trends for vehicle prices in recent years appear to be due in part to changes in the mix of vehicles sold. EPA agrees that access to credit is likely to be more difficult for more expensive vehicles, but with some caveats. First, as EPA has previously discussed, we do not expect price increases as large as those provided in the CAR Report cited by some automakers. Second, a number of lending institutions do provide some reduction in interest rates for more efficient vehicles. Third, EPA has examined the role of the debt-to-income ratio in loans for new vehicles, and there does not appear to be a strict boundary beyond which a potential borrower cannot get a vehicle loan. Fourth, lower-priced vehicles continue to exist, and appear to be gaining new features while staying low-priced. EPA agrees that longer-term loans reduce monthly payments by extending loan periods; these longer-term loans may put some purchasers at risk of owing more than their vehicles are worth at some future time. Baum and Luria,[59] cited by UCS, argue

[59] Baum, A., and D. Luria. (December 21, 2016). "Fuel economy rules a bogeyman for long-term trends in auto

that these trends are due in large part to factors other than the standards; they argue that automakers are focusing their sales efforts on higher-profit, higher-trim models, for instance. Many of the concerns raised about the future of vehicle sales due to rising interest rates and stagnant incomes are happening regardless of the standards. As we have previously argued, the role of the standards in vehicle sales is likely to be secondary to these larger impacts. EPA observes, regardless, that the fuel savings provide more money for people to pay their loans.

EPA did not cite the Wagner et al. (2012) study because, in the 2012 FRM, it found it significantly flawed (see 77 Federal Register 62950-62951). We also do not estimate the number of households who would not be able to get loans due to the standards, as recommended by Ford, because doing so would require identifying which households were likely to buy new vehicles; we are not aware of data that reflect both likelihood to purchase a vehicle, what the expected vehicle price would be for that household, and the detailed financial data needed to identify the household's likely ability to get a loan. (One of the flaws in Wagner et al. was that it did not separate households likely to purchase new vehicles from those unlikely to purchase new vehicles).

3.4 Employment

Summary of Comments on the Draft TAR addressed in the Proposed Determination

Section IV.B. of the Proposed Determination and Section B.2 of the Appendix to the Proposed Determination discussed EPA's assessment of the effects of the standards on employment. These sections, plus Section B.1.3 of the Appendix and TSD Chapter 4.2.1 include an overview of the comments EPA received on this topic in the Draft TAR and EPA's responses to these comments.

Some comments criticized EPA for not quantifying the effects of changes in vehicle sales on employment in the auto sector. As EPA discussed in Section B.2.4 of the Appendix to the Proposed Determination, EPA did not quantify this effect because of its lack of confidence in estimates of the sales impacts of the standards. Sections B.1.3.3 of the Appendix and TSD Chapter 4.2.1 include comments on quantified estimates of the effects of the standards on sales and employment. Some comments asked EPA to incorporate "multiplier" effects into its employment estimates. Multipliers estimate the effects in the broader macroeconomy of impacts in the regulated sector. Appendix Section B.2.3 points out that using multipliers for national-scale analysis is only appropriate when the economy suffers from significant involuntary unemployment. Other comments pointed out the potential for both employment gains and employment losses in industries related to the auto industry. As Appendix Sections B.2.4 and B.2.5 respond, net effects on overall employment depend heavily on the state of the macroeconomy, as jobs may shift among sectors. The Proposed Determination concluded that for the regulated sector, the partial employment impact due to the substitution effect of increased costs of vehicles is expected to be positive. EPA did not estimate the total effects of the standards in the regulated industry because the total effect of the standard on motor employment depends, at least in significant part, on changes in vehicle sales; EPA found these estimates too unreliable to quantify. (EPA also indicated that such quantification is not required by either the Midterm Evaluation rules, or section 202(a)(1) of the Act, concluding that it is better to make reasonable

industry." The Hill. http://thehill.com/blogs/congress-blog/energy-environment/311281-fuel-economy-rules-a-bogeyman-for-long-term-trends-in, accessed 01/09/2017.

albeit qualitative predictions than insufficiently supported quantitative estimates. See Proposed Determination at p. A-87).

Summary of Comments on the Proposed Determination

The Blue-Green Alliance (BGA), Center for Biological Diversity, Environmental Defense Fund (EDF), Woodward, and a joint letter from 74 environmental groups point to the growth in employment in the auto industry since the recession, the first sustained period of job growth in the industry since 1999 (BGA). They argue that the standards have increased employment, in part because of the innovation that the standards have triggered. BGA points to "more than 1,200 factories and engineering facilities in 48 states" (p. 2) producing fuel-saving technologies or the materials for them. EDF points to employment gains associated with the innovation in the Ford F-150, listing 7 domestic plants with significant employment and investment associated with that vehicle. BGA argues that job growth depends on innovation, investment, and manufacturing in the U.S., to which the standards have contributed. UAW also notes that the GHG standards have spurred investments in new products that employ tens of thousands of its members.

The Alliance of Automobile Manufacturers and Fiat Chrysler assert that EPA is deficient because it has not fully quantified employment impacts. The Alliance claims that EPA has not assessed economic impacts to the auto industry. The Union of Concerned Scientists cites a study from Ceres arguing that the industry will be profitable under the standards, even with low fuel prices. The Alliance points out that EPA cited a "projection and analysis of the likelihood of mass unemployment and bankruptcy for a large U.S. automaker based on connection with the promulgation of much less stringent standards" (p. 20), 74 Fed. Reg. 49485, a reference to the reference case analysis in the NPRM for the MY2012-2016 standards. Fiat Chrysler argues that the partial quantification that EPA uses is misleading, and suggests that EPA wait because it "is currently developing a comprehensive model for studying the economy-wide effects of the National Program" (p. 24).

The Center for Automotive Research (CAR) explains that it does not quantify substitution effect employment in its analysis because it finds that expenditures and sales on vehicles decrease, indicating that consumers do not want the added content associated with the increased cost. In addition, CAR argues that the new technologies substitute for existing technologies, and thus do not add labor. EDF and UCS, on the other hand, state that suppliers gain from the standards. BGA, the International Council for Clean Transportation (ICCT), the Natural Resources Defense Council, and UCS point out that innovative technologies spur employment in other industries; indeed, weakening standards would put jobs and competitiveness at risk.

The Alliance, in comments on EPA's substitution effect analysis, requests that EPA adjust its substitution effects multiplier due to increases in productivity over time, and should account for "factor shift effects" due to decreases in employment for some technologies. In discussion of the substitution effect, the Alliance commented that electrified vehicles pose particular threats to auto sector employment, citing the potential for significantly reduced labor content in large, consolidated parts such as batteries and electric motors, and speculating (based on an informal comment describing the aspirations of one manufacturer) that BEV production lines may someday eliminate workers entirely (p. 23-24, the Alliance comments). Also discussing the substitution effect, FCA suggested that many of the jobs created by production of lithium-ion batteries (implicitly in a scenario of higher market penetration than anticipated by the EPA projections) will be created overseas where the currently leading manufacturers are based, not in the U.S.

EDF points out that exports have increased; Honda for instance, is a net exporter from the U.S.

BGA, EDF, and UCS also observe that improved fuel economy reduces the exposure of the auto industry to fuel price shocks, and therefore reduces employment fluctuations that have resulted from that historic exposure.

Consumer Federation of America (CFA) points to employment gains from consumer savings on fuel: as consumers switch from spending on fuel to other goods, they will increase economic output and personal welfare.

UCS mentions a study from Dziczek et al. (2016)[60] on how differences in fleet mix for light trucks across the auto industry leads to non-uniform employment impacts, focusing on whether the most profitable trucks will be able to meet the standards. UCS notes issues with the technical analysis in the study (such as including medium- and heavy-duty pickups that are not subject to these standards), and comments that its use of multipliers for employment impacts overstates the likely impacts.

Response to Comments on the Proposed Determination

Employment has increased in the auto industry as it has recovered from the recession, as various commenters observe. We also agree that the standards have stimulated research and innovation, and that there are employment gains both directly in the innovation effort and in producing fuel-saving technologies. We also agree that the auto industry has been able to achieve the standards while being highly profitable. EPA describes the employment impacts associated with producing the new technologies the “substitution effect,” discussed more below.

EPA disagrees that it has not assessed economic impacts to the auto industry. The basis for this claim appears to be EPA’s not quantifying sales and employment impacts of the standards. In the Proposed Determination, consistent with section 86.1818-12(h)(v) and (viii), EPA evaluated potential employment impacts. See PD App. B.2. We considered potential impacts on the regulated sector, as well as on other directly related sectors (e.g. motor vehicle parts manufacturing, auto dealers, and fuel suppliers). We considered costs for the regulated sector both for the industry as a whole and at the individual firm level. In doing so, we discussed and evaluated both the output effect (relation of production changes and labor demand) and substitution effect (if output is constant, how regulation affects labor-intensity of production), quantifying the second of these. Id. at B.2.4.2.

Commenters reiterated their arguments that this analysis was necessarily deficient because it failed to quantify output effects and to fully quantify substitution effects. As EPA indicated, however, neither the rules establishing the MTE, nor section 202(a) of the Act, contain any requirement that estimates of employment impacts be quantified. See, e.g., id. at A-87. The commenters did not cite any legal principle that would compel such quantification here, nor is

[60] Dziczek, K., B. Smith, Y. Chen, M. Schultz, and D. Andrea (2016). “The economic implications of potential NHTSA and EPA regulatory revisions on U.S. light truck sales and manufacturing.” Center for Automotive Research. www.cargroup.org/?module=Publications&event=View&pubID=145, accessed 01/05/2017.

EPA aware of any. Indeed, courts have supported qualitative determinations for decisions that are even more consequential. See *American Trucking Associations v. EPA*, 283 F. 3d 355, 362 (D.C. Cir. 2002) (upholding qualitative determinations in establishing primary National Ambient Air Quality Standards); *American Farm Bur. Fed. v. EPA*, 559 F. 3d 512, 535 (D.C. Cir. 2009) ("It is true that the EPA relies on a qualitative analysis to describe the protection the coarse PM NAAQS will provide. But the fact that the EPA's analysis is qualitative rather than quantitative does not undermine its validity as an acceptable rationale for the EPA's decision"). EPA reasonably explained, and repeats here, that it chose not to further quantify employment impact estimates due to legitimate uncertainties in the validity of such estimates – based on a close survey of the peer-reviewed literature, as well as careful consideration and discussion of the various quantitative estimates in the public comments. Proposed Determination Appendix B.2.4 and B.2.5. EPA concluded that "EPA views it preferable to consider an issue with reliable qualitative information than unhelpfully wide-ranging estimates." Id. at A-87. Such an approach again has judicial support. See, e.g., *State of Mississippi* v. *EPA*, 744 F. 3d 1334, 1352 (D.C. Cir. 2013) (referring to "the inviolable law" of "garbage in, garbage out" in upholding EPA decision to place minimal weight on quantified risk assessment in revising the National Ambient Air Quality Standard for ozone).

The Alliance implies since EPA evaluated the likelihood of mass unemployment and bankruptcy for a large U.S. automaker" under "much less stringent standards" the current standards could therefore be expected to lead to mass unemployment and bankruptcies for automakers. This is an incorrect implication. The quote refers to the financial status of Chrysler in 2009, which was highly uncertain. In developing its reference case for the MY2012-2016 standards, which EPA proposed in 2009, it acknowledged the then-uncertain status of that company. Clearly Chrysler's financial status was not due to compliance with those standards, which had not even been proposed at the time of Chrysler's difficulties, and there is no reason to believe that the current standards will lead to mass unemployment or bankruptcy for a large U.S. automaker.

Unlike Fiat Chrysler, EPA does not consider its partial quantification misleading. The discussion of the effects is clear that we do not fully quantify employment effects; Fiat Chrysler as well as others understood EPA's employment analysis sufficiently to criticize us for not fully quantifying effects. Fiat Chrysler is incorrect that EPA's Science Advisory Board panel is "developing" a model for economy-wide effects; rather, the panel is examining the suitability of such models for regulatory analysis.[61] While the findings of the panel will be helpful in informing future regulatory work, they will not provide a model suitable for use in this determination, regardless of timing.

EPA addresses CAR's comments on substitution effect employment in Chapter 3.1 of this RTC document, in the context of other comments on CAR's report. As we note there, CAR's explanation appears to be about the output effect, not the substitution effect. In addition, EPA finds that part of the costs of the new technologies is labor, regardless of whether the technologies substitute for existing components.

[61] McGartland, Al (2015). "Transmittal of Charge to the Science Advisory Board Advisory Panel on Economy-Wide Modeling of the Benefits and Costs of Environmental Regulation." https://yosemite.epa.gov/sab/sabproduct.nsf/0/07E67CF77B54734285257BB0004F87ED/$File/Charge%20Questions%202-26-15.pdf , accessed 01/09/2017.

EPA long ago adopted the practice requested by the Alliance that it adjust its multipliers due to increases in productivity over time; it uses historic trends in productivity to adjust its future multipliers (see, e.g., pp. A-90 to A-91 of the Appendix to the Proposed Determination). We note that automation has been a significant force behind changes in employment in the auto sector for decades, independent of the standards. Though "factor shift" employment might be lower for some technologies, such as battery and motor production, it may increase with other technologies; for instance, in the RIA for the MY2017-2025 standards (Table 8.2-4, p. 8-31), EPA provided estimates of the increased labor associated with some of the technologies expected to be used to meet the standards, based on the FEV teardown studies mentioned by the Alliance.

Regarding the employment effects of electrification, while early dominance in lithium-ion batteries was overseas, domestic production has been introduced almost in tandem with introduction of volume-production PEVs such as the Leaf and Volt: Nissan and LG Chem both built large battery manufacturing facilities in the U.S. several years ago. Tesla has just started production at the Gigafactory, which is expected by 2018 to produce over 35 GWh/year, "nearly as much as the rest of the entire world's battery production combined,"[62] and create 6,500 jobs by 2020. We note that the weight of battery packs, and shipping considerations (flammability) likely have played a part in the decision to manufacture these bulky and volatile items domestically; for those manufacturers not currently producing battery packs in the U.S., these factors are likely to continue to exert pressure as a way to keep costs low in the future. The Bloomberg article cited above says 95% of the Tesla Model 3 components will be made in the U.S., suggesting that electrification need not inherently send jobs overseas.

EPA agrees with BGA, EDF, and UCS that reducing auto industry exposure to shocks in fuel prices should reduce fluctuations in sales and employment in the auto industry. EPA also agrees with CFA that consumers will benefit from being able to transfer expenditures on fuel to other goods. Though, as discussed in Appendix Section B.2.5.2 and B.2.5.3, there may be reduced employment in sectors related to fuel supply, there are likely to be increases in employment due to substituting expenditures on fuel to expenditures in other sectors. EPA agrees with UCS that the use of multiplier impacts, as in the Dziczek et al. study, is not appropriate in the context of a national program; see the discussion in Section B.2.3 of the Appendix to the Proposed Determination.

[62] Tesla Team (January 4, 2017). "Battery Cell Production Begins at the Gigafactory." https://www.tesla.com/blog/battery-cell-production-begins-gigafactory , accessed 01/05/2017; Randall, Tom (January 4, 2017). "Tesla Flips the Switch on the Gigafactory." Bloomberg News, https://www.bloomberg.com/news/articles/2017-01-04/tesla-flips-the-switch-on-the-gigafactory , accessed 01/05/2017.

3.5 Economic and Other Key Inputs

Summary of Comments on the Draft TAR addressed in the Proposed Determination

In the Draft TAR, the agencies documented in detail how we developed several input values used in various economic and other analyses. Except as discussed below, EPA did not receive comments on the following economic and other input values presented in the Draft TAR:

- On-road Fuel Economy Gap
- Fuel Prices
- Rebound Effect
- Energy Security
- Reduced Fueling Time Benefits
- Impacts of Additional Driving
- Discounting Future Benefits/Costs
- Additional Costs of Vehicle Ownership

Regarding the social cost of carbon (SCC), several comments received on the Draft TAR stated that the SC-CO_2, SC-CH_4, and SC-N_2O underestimates climate-related benefits and discussed some of the technical details of the modeling conducted to develop these estimates. As noted in the TSD Chapter 3.7, EPA recognizes the importance of the estimates to be as complete as possible and will continue to follow and evaluate the latest science on impact categories that are omitted or not fully addressed in the integrated assessment models.

One commenter also recommended that EPA use undiscounted estimates of the SC-CO_2. Consistent with the recommendations of the Interagency Working Group (IWG) on SC-GHG, EPA continued to apply the SC-GHG values discounted at rates of 2.5, 3.0, and 5.0 percent. EPA identified these discount rates in the TSD Chapter 3.7, and referred to the Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866 (February 2010) ("2010 TSD") for a complete discussion of the methods used to develop the estimates, including the discount rates. In sum, the 2010 TSD concluded that arguments made under the prescriptive approach can be used to justify discount rates between roughly 1.4 and 3.1 percent but that concerns about the most appropriate value for η (i.e., the parameter capturing diminishing marginal utility) make it difficult to justify rates at the lower end of this range under the Ramsey framework. Therefore, in light of disagreement in the literature on the appropriate market interest rate to use in this context and uncertainty about how interest rates may change over time, the IWG used three discount rates to span a plausible range of certainty-equivalent constant discount rates: 2.5, 3, and 5 percent per year. The IWG further noted that these three rates reflect reasonable judgments under both descriptive and prescriptive approaches.

Some commenters also provided constructive recommendations for potential opportunities to improve the SC-CO_2 estimates in future updates. EPA responded in TSD Chapter 3.7 that the U.S. government is seeking input from the National Academies of Sciences, Engineering and Medicine on how to approach future updates to ensure that the estimates continue to reflect the best available scientific and economic information on climate change. An Academies committee, "Assessing Approaches to Updating the Social Cost of Carbon," (Committee) will provide its final report in early 2017 with advice on the merits of different technical approaches for modeling and highlight research priorities going forward. In the meantime, the IWG continues to recommend the use of the current SC-CO_2 estimates as the best scientific information on the impacts of climate change available in a form appropriate for regulatory analysis. EPA expects that, as in the case of the 2013 SC-CO_2 update, any future updates to IWG SC-GHG guidance based on the Academies' recommendations will apply to regulatory impact analyses going forward.

Several commenters suggested that the vehicle Mileage Accumulation Rates (MAR) should not be changed from values used in the FRM analysis for our Proposed Determination assessment. EPA responded in TSD Chapter 3.1 reiterating the value of using the most current values for the MAR rates (as found in the Annual Energy Outlook 2016).

EPA received a few public comments on the Draft TAR, relating to the omission of certain non-GHG impacts from the analysis of the program. As we explained in TSD Chapter 3.6, and have explained in earlier comment periods associated with the light-duty vehicle GHG program, there are several health benefit categories that EPA is unable to quantify due to limitations associated with using $PM_{2.5}$-related benefit per-ton estimates, several of which limitations have the possibility to be substantial (i.e. to underestimate health benefits). For example, we are not able to quantify a number of known or suspected health benefits linked to reductions in ozone and other criteria pollutants, as well as health benefits linked to reductions in air toxics. In addition, we are unable to quantify a number of known welfare effects, including reduced acid and particulate deposition damage to cultural monuments and other materials, and environmental benefits due to reductions of impacts of eutrophication in coastal areas. As a result, the health benefits quantified in the Draft TAR and TSD were likely underestimates of total non-GHG-related benefits associated with the program. For this reason, for the analyses in the Proposed Determination, EPA recognized that the omission of these benefits would not change EPA's overall policy conclusions about the appropriateness of the existing standards. The Proposed Determination acknowledged that their inclusion would only increase the amount by which the quantified benefits outweigh the program's estimated costs.

Summary of Comments on the Proposed Determination

Energy Security: EPA received one comment on the energy security impacts of the Proposed Determination. This commenter noted that the LDV standards enhance the energy security position of the U.S. by significantly reducing U.S. imports of oil over time.

Social Cost of GHGs: EPA received two comments on the Proposed Determination that discussed the social cost of CO_2, also referred to as the social cost of GHGs (SC-GHG), to include estimates of the social cost of non-CO_2 GHGs, such as CH_4 and N_2O. Of these comments, one supported the application of the social cost of carbon to monetize CO_2, CH_4, and N_2O impacts. This commenter also stated that the SC-GHG values used by EPA and other federal agencies are underestimates, due in part to omission of key climate change impacts, and that the 3 percent discount rate applied to the SC-GHG values is too high. The second SC-GHG comment letter stated that the precise magnitude and sign of the social cost of carbon is in question. This second commenter also noted that they submitted a letter to the Office of Management and Budget's separate comment solicitation on the SC-GHG (78 FR 70586; November 26, 2013); the comment period for this separate OMB solicitation ended on February 26, 2014.

Response to Comments on the Proposed Determination

Energy Security: EPA agrees with the commenter that the Proposed Determination will improve the energy security position of the U.S. by reducing oil imports.

Social Cost of GHGs: EPA agrees with the comment that the application of the SC-GHG values in benefit-cost analysis is appropriate. The comments about omitted climate change impacts and the discount rates applied to the SC-GHG are identical to those received on the Draft TAR. Please see the summary above, "Summary of Comments on the Draft TAR addressed in the Proposed Determination," for details about EPA's response.

Regarding the second comment letter on SC-GHG, which made note of comments submitted to a separate OMB solicitation on SC-GHG, EPA notes that the interagency working group (IWG) on the SC-GHG responded to all of the comments submitted to OMB through that separate comment solicitation on the SC-GHG (78 FR 70586; November 26, 2013). As a member of the SC-GHG IWG, EPA carefully examined and evaluated comments submitted to OMB's separate solicitation. EPA has determined that the IWG responses to the comments on the OMB solicitation address the comments on the SC-GHG methodology, including the magnitude and sign of the SC-GHG estimates, the selection of discount rates, the use of global measures, climate sensitivity, damage functions, and other market impacts. Specifically, EPA concurs with the IWG's response to these comments and hereby incorporates them by reference.[63] The second comment letter also noted the uncertainty of the SC-GHG estimates. While EPA acknowledges uncertainty in the SC-GHG estimates, EPA disagrees with the commenter's implication that the uncertainty is so great as to undermine use of the SC-GHG estimates in regulatory impact analysis. The uncertainty in the SC-GHG estimates is fully acknowledged and comprehensively discussed in the SC-GHG TSDs and supporting academic literature. While uncertainty must be acknowledged and addressed in regulatory impact analyses, even an uncertain analysis provides useful information to decision makers and the public.

After careful evaluation of the full range of comments on the SC-GHG received through the Draft TAR, the Proposed Determination, and other comment solicitations related to SC-GHG, EPA has determined that use of the current SC-CO_2, SC-CH_4, and SC-N_2O estimates is appropriate and that the current estimates continue to represent the best scientific information on the impacts of climate change available in a form appropriate for incorporating the damages from incremental GHG emissions changes into regulatory analysis.

[63] Referred to as the "OMB Response to Comments on SC-GHG." See https://www.whitehouse.gov/sites/default/files/omb/inforeg/scc-response-to-comments-final-july-2015.pdf. For the issues highlighted in the comment letter submitted to the Proposed Determination, see OMB Response to Comments on SC-GHG, pages 3, 9-10, 25-28, 29-30 (the magnitude and sign of the SC-GHG estimates, uncertainty), pages 20-25 (the selection of discount rates), pages 30-32 (the use of global measures), pages 11-17 (climate science, including climate sensitivity), pages 6-11 (damage functions), and page 11 (other market impacts).

3.6 Safety

Summary of Comments on the Draft TAR addressed in the Proposed Determination

EPA received a few public comments on the mass/safety analysis contained in Chapter 8 of the Draft TAR. Natural Resources Defense Council (NRDC) stated a strong belief that the 2025 standards can be achieved without an increased risk to safety, and that the fleet of future vehicles can be built lighter weight, less polluting and safe. The Alliance of Automobile Manufacturers commented that it found inconsistencies in the results "that require further physical explanations." Tom Wenzel, of Lawrence Berkeley National Laboratory (LBNL), on behalf of Department of Energy (DOE), recommended that the agencies should use a second set of regression coefficients, such as those used in the "LBNL baseline"[64] to run EPA's OMEGA model, "because the estimated relationships between mass reduction and societal fatality risk are not consistently statistically different from zero, and are sensitive to the data and variables used in the regression models."

As we discussed in Section B.3.1 of the Proposed Determination Appendix, and more specifically indicated at Table B.8 of that document, if we were to apply Wenzel's "LBNL baseline" in our OMEGA model, the estimates of potential adverse safety implications would be even lower, which might influence a choice to model greater levels of mass reduction in assessing potential compliance pathways. We acknowledged the rationale for Wenzel's recommendation. However, for purposes of the Proposed Determination, we believed it appropriate to continue using the approach taken in the Draft TAR, since it was more conservative and we wanted to ensure there are no significant adverse safety implications associated with the 2022-2025 standards.

Summary of Comments on the Proposed Determination

NRDC and the Alliance of Automobile Manufacturers (the Alliance) commented on the safety analysis presented in the Proposed Determination. NRDC states its belief that the analysis is conservative because it "continues to rely on the conservative assessment from the TAR," and recommends that future assessments of safety impacts should include inputs (e.g. regression coefficients) that account for deficiencies identified by Tom Wenzel of Lawrence Berkeley National Laboratory (LBNL). The Alliance claims EPA did not address in the Final Determination its two concerns over the Draft TAR safety analysis. One concern was EPA's use of "two highly correlated factors (mass and footprint) in a regression analysis," which was described as having the potential to lead to non-physical results. The other concern was "the apparent disconnect between the EPA Draft TAR safety analysis and the NHTSA 2016 VOLPE Report," which refers to inconsistencies between Table 3-7 of NHTSA's 2016 Volpe Report and Table 8.7 of the Draft TAR. The Alliance states that "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" and states that EPA offers no explanation for the difference.

[64] Tom Wenzel, Table 5.16, "Assessment of NHTSA's Report "Relationships Between Fatality Risk, Mass, and Footprint in Model Year 2003-2010 Passenger Cars and LTVs, Preliminary report prepared for the Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy." LBNL -1005177. (July, 2016).

Response to Comments on the Proposed Determination

We agree with NRDC that EPA's analysis in the Proposed Determination based on the assessment from the Draft TAR is conservative as compared to Wenzel's recommended "LBNL baseline," which might influence a choice to model greater levels of mass reduction in assessing potential compliance pathways. However, we believe the conservative approach taken in the Proposed Determination is appropriate, since we want to ensure there are no significant adverse safety implications associated with the 2022-2025 standards as we have stated previously.

The comment made by the Alliance asserting that EPA did not address its concern in the Proposed Determination on "EPA's use of two highly correlated factors (mass and footprint) in the regression analysis" is not accurate. First, EPA did not perform its own safety statistics (regression) analysis. We relied on the Draft TAR's safety statistics results as inputs to the OMEGA model in the Proposed Determination. Second, the issue of "use of two highly correlated factors (mass and footprint) in a regression" was discussed and reviewed extensively in Chapter 8 of the Draft TAR. We believe using two or more variables that are strongly correlated in the same regression model (referred to as multicollinearity) can lead to inaccurate results. However, the correlation between vehicle mass and footprint may not be strong enough to cause serious concern. See Draft TAR, Chapter 8.2.4.6, p. 8-33. As stated at page 4, Executive Summary in the NHTSA 2016 preliminary report,[65]

> "NHTSA considered the near multicollinearity of mass and footprint to be a major issue in the 2010 report and voiced concern about inaccurately estimated regression coefficients.[66]… Nevertheless, multicollinearity appears to have become less of a problem in the 2012 and 2016 analyses. The "decile" analysis comparing fatality rates of vehicles of different mass but nearly identical footprint (modified in 2012 in response to peer-review comments to control for factors such as driver age and gender) largely corroborates the main regression results. Ultimately, only three of the 27 core models of fatality risk by vehicle type indicate the potential presence of effects of multicollinearity, with estimated effects of mass and footprint reduction greater than two percent per 100-pound mass reduction and one-square-foot footprint reduction, respectively: passenger cars and CUVs in first-event rollovers, and CUVs in fixed-object collisions."

The second issue raised by the Alliance, regarding their contention that there is a disconnect between the EPA Draft TAR safety analysis and the NHTSA 2016 VOLPE Report, speaks to inconsistencies between NHTSA's 2016 Volpe Report (Table 3-7) and Table 8.7 of the Draft TAR. However, Table 8.7 of the Draft TAR is a table authored by NHTSA, showing results from the CAFE model. EPA does not agree that there is any implication for the EPA GHG analysis presented in the Draft TAR or the Proposed Determination. It is possible that the Alliance meant to point to Draft TAR Tables 8.3 and 8.4 which do show fatality impacts per 100 lb mass reduction. In the Draft TAR, and again in the Proposed Determination, EPA used values

[65] Puckett, S.M. and Kindelberger, J.C. (2016, June). Relationships between Fatality Risk, Mass, and Footprint in Model Year 2003-2010 Passenger Cars and LTVs – Preliminary Report. (Docket No. NHTSA-2016-0068). Washington, DC: National Highway Traffic Safety Administration.

[66] Van Auken and Green also discussed the issue in their presentations at the NHTSA Workshop on Vehicle Mass-Size-Safety in Washington, DC on February 25, 2011, http://www.nhtsa.gov/Laws+&+Regulations/CAFE+-+Fuel+Economy/NHTSA+Workshop+on+Vehicle+Mass-Size-Safety.

consistent with Draft TAR Table 8.4. However, that table does not present a value of 91 or 55 as stated by the Alliance, so we cannot determine what is the inconsistency of concern. Importantly, Draft TAR Table 8.4 shows results of NHTSA's 2016 Preliminary Report while Table 8.3 shows results of the 2012 Final Report. EPA did not use results from the 2012 report.

3.7 Alternative Fuel (PEV) Infrastructure

Summary of Comments on the Draft TAR addressed in the Proposed Determination

Although the Draft TAR projected that meeting the MY2025 standards will require only a very small fraction of PEVs in the fleet, alternative fuel vehicles such as battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), and fuel cell electric vehicles (FCEVs) are likely to be an essential part of any future vehicle fleet intended to meet long term climate and air quality goals. In addition, other alternative fuels such as ethanol (E85) and compressed natural gas (CNG) have the potential to contribute to GHG emission reductions. Chapter 9 of the Draft TAR provided an overview of alternative fuel vehicle infrastructure, including the status, costs, and trends in PEV charging infrastructure and hydrogen fueling infrastructure, and examined the challenges being addressed to scale up the infrastructure as advanced vehicle sales grow in response to market demand and for compliance with the federal standards. Chapter 9 of the Draft TAR concluded that infrastructure does not present a barrier for the small numbers of alternative fuel vehicles that we expect manufacturers to choose to produce as a part of their compliance with the MY2022-2025 GHG standards.

In public comments on the Draft TAR, several stakeholders discussed the conclusions of the Draft TAR about the sufficiency of existing and expected infrastructure development. A number of these comments, generally from the automotive manufacturing industry, focused on the commenters' belief that a greater degree of infrastructure development would be needed because they expect that more of these vehicles will be needed to meet the standards. However, as discussed in Section III.C.2 and in Appendix B.3.2 of the Proposed Determination, we continue to conclude that only a few percent of PEVs will be needed to meet the standards and thus we also continue to conclude that current and expected expansion of electric charging and hydrogen fueling infrastructure, as discussed in Chapter 9 of the Draft TAR, will be sufficient to supply that segment of the automotive fleet. EPA also responded to comments on infrastructure in TSD Chapter 2.2.4.4.5 at p. 2-97, and also provided additional discussion of charging infrastructure developments in TSD Chapter 2.2.4.3.2 at p. 2-70.

Summary of Comments and Responses on the Proposed Determination

Nissan commented generally that public PEV charging infrastructure is not growing quickly enough to support consumer needs and expectations. Mercedes-Benz provided more detailed comments on charging infrastructure, arguing that the longer charging time required for longer-range PEVs makes 110V (Level 1) charging impractical; that the cost of upgrading electrical service to accommodate home charging at higher rates must be considered; and that public charging in "cities where land is at a premium can also mean higher charging rates outside of the home for consumers." Mercedes-Benz also suggested that EPA had not addressed private infrastructure concerns in the Proposed Determination.

The comment from Nissan concerning general adequacy of growth in charging infrastructure, and the portions of the Mercedes-Benz comments concerning Level 1 charging, private infrastructure concerns, and cost of upgrading electrical service, mirror the concerns outlined in many of the public comments received on the Draft TAR. EPA addressed those comments in Section B.3.2 of the Proposed Determination Appendix at p. A-98 and in TSD Chapter 2.2.4.4.5 at p. 2-97, and also provided additional discussion of charging infrastructure developments in TSD Chapter 2.2.4.3.2 at p. 2-70. Specifically, EPA pointed out several examples of charging infrastructure initiatives that suggest public charging infrastructure will continue to grow; that the cost of installing home charging capability was in fact included in the projected cost of BEVs and PHEVs; and that EPA did not assume that PEV users would rely solely on Level 1 charging but rather on a mix of Level 1 and Level 2 (weighted heavily toward Level 2) depending on the specific PEV type. EPA disagrees that these responses did not address private infrastructure concerns of the sort raised by Mercedes-Benz, in that they referred to the relative capabilities of Level 1 and Level 2 and the fact that EPA had accounted for the costs necessary for installing Level 1 or Level 2 charging service capability and equipment. EPA also notes, as mentioned in the TSD discussion of BEVs in Chapter 2.2.4.4.5 at p. 2-70, that longer-range electric vehicles do not render Level 1 charging useless, in that they are equally capable as shorter-range vehicles of having a given daily mileage replenished on a nightly basis. That is, while a fully depleted battery of a longer-range vehicle would in fact require a longer time to restore to full charge than a shorter-range vehicle, the larger capacity of the battery means that, for a given average daily mileage, depleting the battery completely will rarely happen as long as charge is replaced daily. Stated another way, if the primary requirement of routine daily charging for both longer- and shorter-range PEVs is to achieve a state of charge suitable to meet the driving needs of the next day, then the total capacity of the battery does not inherently affect the average necessary charge time to reach that state of charge. This is not to suggest that Level 1 charging is practical in all situations (such as those where daily mileage is unusually large, or where owners do not wish to charge daily), but only that the usefulness of Level 1 charging in many situations is not inversely related to the range of the vehicle. Also as stated in the responses in the TSD and above, EPA assumed that home installations of charging capability would be significantly weighted toward Level 2 charging, and accounted for the cost of installation accordingly.

With regard to the Mercedes-Benz comment that public charging in “cities where land is at a premium can also mean higher charging rates outside of the home for consumers,” EPA notes that it is commonly understood that real estate costs often have an influence on the retail pricing of many goods and services, and that real estate costs are often higher in densely populated areas. EPA is not aware of data supporting the suggestion that retail public charging rates for consumers in cities should experience this effect more than other similar services, nor that retail public charging rates being paid by consumers are systematically and significantly higher in cities, even as much of the currently available public charging infrastructure in the U.S. is located in cities and urbanized areas of varying density and real estate value. Much of this infrastructure is not accessed through a retail payment mechanism, and is it not yet clear what proportion of future infrastructure will require retail payment, nor which payment models (e.g. flat rate per use, metered, subscription based, etc.) will be common. The existence or magnitude of any supposed differential in charging rates in cities would therefore be very difficult to reliably assess at this early stage of retail public charging infrastructure, and EPA believes that in the context of this analysis any such future charging cost differential, if it were possible to identify and measure, would amount to only a small portion of projected PEV costs and would not affect the overall conclusions of the analysis.

3.8 Standards Design

Summary of Comments on the Draft TAR addressed in the Proposed Determination

In the design of the MY2012-2025 GHG standards, EPA carefully considered the impact the standards can have on vehicle utility and consumer choice such that the automotive companies have the ability to maintain vehicle utility and consumer choice while complying with the standards. EPA decided to use vehicle "footprint" as the attribute to determine the GHG standards for a given automotive manufacturer's fleet (the standard being the production-weighted average of the footprint-based targets for each vehicle produced). The light-duty vehicle GHG standards are curves based on the footprint attribute (Section I of the Proposed Determination shows a graphical depiction of the footprint curves). There are separate passenger car footprint-based standards and light-truck footprint-based standards.

EPA received a variety of comments regarding use of the footprint attribute. Several commenters stressed the importance of the footprint-based standards in ensuring consumer choice and encouraging emissions reductions across vehicles of all sizes. Several commenters expressed concern regarding the footprint standards, asserting that vehicle footprints are increasing over time. Related to the comments regarding footprint, EPA received comments supporting a backstop standard. EPA also received comment on the current light truck definition. Section B.3.3 of the Appendix to the Proposed Determination provided an overview of these comments as well as EPA's response. Because the Proposed Determination was that the standards remain appropriate and the footprint attribute is a key feature of those standards, EPA did not propose to change any aspect of the design of the standards.

Summary of Comments on the Proposed Determination

EPA received comments similar to comments received on the Draft TAR supporting the use of the footprint-based attribute. The UAW commented that well-constructed regulations can protect the environment while simultaneously supporting existing jobs and creating jobs in new advanced technology sectors of the economy. The UAW further commented that the basic design of the National Program was carefully constructed by a wide array of stakeholders and should be kept intact and not dramatically altered. Consumers Union commented that footprint-based standards encourage automakers to design and sell vehicles that have better fuel economy across all vehicle classes. Consumer Federation of America commented that the attribute-based approach ensures that the standards do not require radical changes in the available products or the product features that will be available to consumers. ICCT commented that the footprint standards appropriately accommodate the changing fleet mix due to market shifts. The BlueGreen Alliance also commented that the standards are "smartly structured," adjusting with changes in the mix of cars and trucks while ensuring that no matter how the market shifts, each size of vehicles makes gradual but steady progress.

EPA also received comments similar to those on the Draft TAR raising concerns with the footprint attribute. The Institute for Energy Research commented that EPA has not adequately addressed concerns raised by Whitefoot and Skerlos in a 2012 peer reviewed publication regarding the potential incentive for manufacturers to upsize vehicles in response to footprint-based standards. Carnegie Mellon also referenced the Whitefoot and Skerlos paper and recommended that EPA study recent pickup truck footprint increases as well as footprint trends in other vehicle segments to determine if the footprint-based standards create an incentive for automakers to increase vehicle size. Consumers Union also raised concerns regarding "footprint creep" where manufacturers would increase the footprint of vehicles in order to lower their fleet standard, and recommended EPA consider backstop standards to complement the footprint-based standards. Center for Biological Diversity also commented that a backstop standard is needed to prevent the loss of emissions reductions from shifts in fleet mix and footprint creep. EPA also received an anonymous comment that the footprint standards would restrict vehicle offerings, reducing cabin sizes, and require consumers to purchase larger vehicles than they would otherwise.

Mercedes-Benz commented that the footprint standards cannot compensate for the disparity between large fleets with diverse product offerings and fleets that sell traditionally in the luxury market. Mercedes recommends EPA take a separate action outside of the MTE process to extend the Temporary Lead Time Allowance Alternative Standards (TLAAS) provisions established in the MY2012-2016 rule. Mercedes believes EPA should include more flexibilities for manufacturers who traditionally sell into the luxury market with modest volumes over which to spread their compliance obligations.

EPA received comments from BMW regarding the relative stringency of the car and light truck standards. BMW commented that the stringency gap between cars and light trucks should be further reduced based on physics and with a view toward ever increasing overlap between the two segments. BMW further commented that not every automaker can compensate for a potential compliance shortfall from small passenger cars with a portion of very large light trucks with a comparable relaxed standard.

Response to Comments on the Proposed Determination

Comments regarding the footprint-based standards providing an incentive for manufacturers to increase vehicle footprints, or "footprint creep," and the need for a backstop standard are very similar to comments received on the Draft TAR and addressed in Section B.3.3 of the Appendix to the Proposed Determination. EPA understands the concerns of commenters that the program is now projected to deliver a somewhat higher numerical fleetwide CO_2 target than originally estimated. However, EPA continues to believe that the program is operating as designed, by accommodating shifts in consumer choice in the fleet while requiring increasingly more stringent GHG emission reductions across all vehicle types. EPA disagrees with the Institute for Energy Research that EPA has not adequately responded to concerns regarding footprint. EPA previously addressed the Whitefoot and Skerlos study as part of the 2012 rule.[67] EPA noted that the authors made several assumptions for the study and changes to any of the assumptions could yield different analytic results. Underlining the potential uncertainty, the authors obtained a wide range of results with their analysis. EPA has monitored trends in footprint and has found that average footprint has remained relatively flat since the standards were first established, as discussed in Section B.3.3 of the Appendix to the Proposed Determination. EPA is not aware of any evidence that the standards structure is motivating the shift from cars to trucks, beyond the effect of market forces such as lower gasoline prices. EPA also does not agree with the anonymous comment that the program is restricting vehicle choice and forcing consumers to purchase larger vehicles than they would otherwise. Nothing in the design of the GHG program restricts manufacturers' ability to offer a full range of vehicle sizes and features, including cabin

[67] 77 FR 62962, October 15, 2012.

size. A key feature of the footprint attribute approach is that it provides an incentive for manufacturers to reduce GHGs from vehicles of all sizes without reducing consumer choice.

Mercedes provided comments that EPA should include less stringent standards for smaller volume manufacturers similar to the less stringent standards provided by EPA in the MY2012-2016 rule under Temporary Lead Time Allowance Alternative Standards (TLAAS), in order to provide smaller volume manufacturers with more lead time. EPA does not believe less stringent standards are appropriate or necessary. The TLAAS program was established to provide additional lead time on a temporary basis to lower volume manufacturers in the initial years of the GHG program.[68] The MY2012-2016 standards were finalized in 2010 and additional lead-time was found to be appropriate for lower volume manufacturers. TLAAS was designed to address two situations where EPA projected that more lead time was needed for the initial phase of the GHG program. One situation involved manufacturers who had traditionally paid CAFE fines instead of complying with the CAFE fleet average, and as a result at least part of their vehicle production had significantly higher CO_2 than the industry average. The other situation involved manufacturers who had a limited line of vehicles and are therefore unable to average emissions performance across a full line of production. EPA provided additional lead-time in the initial years for such manufacturers to upgrade their vehicles and meet the standards. EPA did not extend the TLAAS program in the MY2017-2025 rule, which went through a full notice and comment period, because those standards provided significantly more lead time than the first rule and the TLAAS was designed to be temporary.[69] This is especially true for the MY2022-2025 standards, where significant lead time has been provided since the 2012 rule. EPA has determined that the MY2022-2025 standards currently in place remain appropriate under section 202 of the Clean Air Act considering available lead time without the need for less stringent standards for lower volume manufacturers.

Regarding BMW comments concerning relative stringency between car and truck standards, EPA does not believe that the BMW comment is supported by the analysis conducted by EPA in support of the determination. As discussed in the Final Determination document, the Administrator has concluded that the record does not support a conclusion that the MY2022-2025 standards should be revised to make them less stringent. The Administrator did consider whether it would be appropriate to propose to amend the standards to increase their stringency. In her view, the current record, including the current state of technology and the pace of technology development and implementation, could support a proposal, and potentially an ultimate decision, to adopt more stringent standards for MY2022-2025. However, she also recognizes that regulatory certainty and consequent stability is important, and that it is important not to disrupt the industry's long-term planning. Long lead time is needed to accommodate significant redesigns. The Administrator consequently has concluded that it is appropriate to provide the full measure of lead time for the MY2022-2025 standards, rather than adopting (or, more precisely, proposing to adopt) new, more stringent standards with a shorter lead time.

3.9 Credits, Incentives, and Flexibilities

Summary of Comments on the Draft TAR addressed in the Proposed Determination

[68] 75 FR 25414, May 7, 2010.
[69] 77 FR 62795, October 15, 2012.

The National Program provides a wide range of optional flexibilities to allow manufacturers to maintain consumer choice, spur technology development, provide compliance flexibility, and reduce compliance costs, while achieving significant GHG reductions. Chapter 11 of the Draft TAR provided an overview of these provisions which include averaging, banking, and trading of credits, air conditioning system credits, off-cycle technology credits, and advanced technology vehicle incentives including incentives for large pickups using advanced technologies.

EPA received comments on various aspects of the credits programs. Air conditioning system credits and related comments are discussed in Chapter 2.2.9 of the TSD (and are discussed further in Chapter 2.5.16 of this Response to Comments (RTC) document). EPA received a variety of comments supporting both procedural changes to expedite the off-cycle credit approval process, and substantive changes to increase or remove caps on the amount of credits provided without need for prior approval (the so-called menu credits in section 86.1869-12) and to expand the eligibility criteria for receiving off-cycle credits. Other commenters expressed concerns regarding possible changes to the off-cycle credits program. Section B.3.4.1 of the Appendix to the Proposed Determination provided an overview and EPA's response to comments received regarding off-cycle credits. Our conclusion at that time was that the standards for MYs 2022-2025 remain appropriate and therefore that no rulemaking to amend the standards was necessary. Since the Proposed Determination would leave both the standards and all of the regulatory provisions supporting the standards unaltered, EPA did not propose any changes to the off-cycle credit provisions. Those provisions are a part of the standards, and EPA explicitly considered and quantified off-cycle credit usage in evaluating available compliance paths. See also Chapters 2.5.16.1 and 2.8 of this RTC document. Consideration of off-cycle credits under the current standards thus was a direct part of EPA's analysis in the Proposed Determination that the MY2022-2025 standards remain appropriate.

As discussed in Section B.3.4.2 of the Appendix, EPA also received comments regarding incentives for advanced technology vehicles including BEVs, PHEVs, and FCEVs. In response to these comments, EPA noted that it was proposing a determination that would leave the MY2022-2025 standards unchanged based on the existing regulatory program and therefore did not propose any changes to these programs. Put another way, EPA proposed a determination that took into account the existing regulatory provisions on incentives for advanced technology vehicles (just as it proposed to find the standards appropriate considering the current regulations regarding off-cycle credits). In addition to the request for comment on EPA's proposed determination, EPA requested comments on the need to continue incentives for advanced technology vehicles, including for the MY2022-2025 time frame.

As discussed in Section B.3.4.3 of the Proposed Determination Appendix, EPA also received comments regarding incentives for flexible fuel vehicles and natural gas vehicles as well as credits for investments in alternative fuel infrastructure. EPA responded that, as with off-cycle credits, the Proposed Determination was that the MY2022-2025 standards remain appropriate and that the Proposed Determination took into account the standards' flexibilities as they now stand, including the incentives for flexible fuel vehicles and the advanced technology incentives.

Summary of Comments on the Proposed Determination

EPA received several comments on the topic of off-cycle credits. Many of the comments were essentially the same as comments provided on the Draft TAR. Mercedes-Benz provided several suggestions it believes would improve the program including removing the menu credit cap, adding technologies to the menu via guidance, allowing suppliers to participate in the program, allowing all manufacturers to receive the same credits approved for a manufacturer through the approval process, and streamlining the approval process for unique technologies. Mercedes-Benz commented, also, that credits should be provided for congestion mitigation and crash avoidance and that the agency should work with interested parties to devise an acceptable methodology for determining these credits. Mercedes requested that EPA issue guidance or initiate a rulemaking to improve the off-cycle credits program. BMW commented that EPA should expand the menu of technologies, include credits for European off-cycle technologies, and include credits for reduced traffic, faster exchange of older vehicles for new, more fuel efficient vehicles, car sharing, and establishing charging infrastructure for electric vehicles. The Alliance asserted that EPA dismissed their Draft TAR comments regarding off-cycle credits, in which they suggested expanding the credit menu, removing the credit caps, and providing additional credits for 48V mild hybrids.

The Motor and Equipment Manufacturers Association (MEMA) commented that it disagrees with EPA's Proposed Determination finding that the standards remain appropriate with no changes to the off-cycle credits program, asserting that "further development of and improvement to the off-cycle credits program is necessary to provide much needed flexibilities and allow industry to stay on track for MYs 2022-2025." MEMA believes that EPA should wait to consider MY2015-2017 usage of off-cycle credits before determining no changes are needed to meet the MYs 2022-2025 standards. MEMA recommended that EPA consider how off-cycle credits can be optimized even if it is outside of the MTE process, including expanding the predefined menu, removing the menu credit cap, streamlining the process and allowing suppliers to directly petition for approval of new off-cycle technologies.

Denso reiterated their comments supporting changes to the off-cycle credits program to streamline the process and encouraging EPA to develop a working group to facilitate standardized test methods. Denso also encouraged EPA to consider future updates to the off-cycle credits program, based on the relevancy of advanced technologies in future model years.

American Iron and Steel Institute (AISI) commented that EPA should include GHG emissions from the material production phase to ensure that the program results in the greatest GHG reductions. AISI commented that depending on the mix of materials used in the vehicle, particularly in the context of vehicle light-weighting, increases in material production emissions may be higher in magnitude than tailpipe savings. AISI commented that developing an off-cycle credit would be an option that could help account for differences in materials production phase emissions.

EPA also received comments, similar to Draft TAR comments, expressing concern regarding any expansion of the off-cycle credits program. ACEEE commented that EPA's analysis demonstrates that commenter claims that manufacturers will need large quantities of off-cycle credits to comply with the standards is incorrect. ACEEE reiterated their Draft TAR comments that the changes to the off-cycle credits program suggested by the automotive industry could undermine the credibility of the program and the effectiveness of the standards. The Center for Biological Diversity commented that the program must avoid double counting, the credits awarded must be demonstrated to translate to actual real-world on-road improvements, and that credits should not be approved until such studies have been completed.

In addition to EPA's request for comments on the Proposed Determination, EPA requested comments on the need for continued incentives for advanced technologies such as plug-in hybrid electric vehicles, battery electric vehicles, and fuel cell vehicles. EPA received comments supporting extending advanced technology incentives similar to comments received on the Draft TAR, including from the Alliance, Global Automakers, Ford, Mercedes-Benz, BMW, Nissan, Toyota, Center for Biological Diversity, and Edison Electric Institute. The commenters supported extending the incentive multipliers and the continued use of 0 g/mile tailpipe compliance value for electric operation with no accounting of upstream emissions to continue to encourage advanced technology vehicles. Ford also commented in support of a credit to incentivize HEVs, noting that sales of HEVs have been stagnant or declining since 2013. Manufacturers reiterated comments that they should not be held responsible for upstream emissions since they have no control over those emissions and that upstream emissions are addressed under EPA's Clean Power Plan. Toyota also commented that EPA did not respond to the Alliance, Toyota and other comments received on the Draft TAR regarding expanding advance technology incentives for full size pickups. Mercedes requested that EPA initiate a rulemaking to extend/expand incentives for advanced technology vehicles.

EPA also received comments opposing extending or expanding the advanced technology incentives. Commenters against expanding the incentives included Manufacturers of Emission Controls Association, Carnegie Mellon University, ACEEE, and UCS. The commenters believe that additional incentives are not needed to encourage advanced technologies, with some commenters noting that EPA's analysis shows the standards are feasible with low penetrations of electric vehicles. Commenters were also concerned that expanding the incentives would reduce the overall benefits of the program, and that advanced technology vehicles should compete in the marketplace on the same basis as other technologies. ACEEE commented that the Clean Power Plan is currently being litigated and therefore they do not find the Alliance's rationale for eliminating the accounting of upstream emissions for electric operation persuasive at this time. One commenter believed that the CAFE credit for BEVs and PHEVs lack a compelling thermodynamic basis in terms of equitable system-level energy substitutions between oil and electricity.

EPA received comments on the Proposed Determination supporting incentives for flexible fuel vehicles and natural gas vehicles as well as credits for investments in alternative fuel infrastructure similar to comments received on the Draft TAR.

Mercedes-Benz commented that EPA should allow credits to be transferred to the light-duty fleet from heavy-duty 2B/3 class vehicles in order to provide manufacturers with additional flexibility. Mercedes also commented that EPA should consider the potential lack of future availability of a credits market and traded credits from one manufacturer to another.

<u>Response to Comments on the Proposed Determination</u>

Most of the comments on off-cycle credits were essentially the same as comments submitted on the Draft TAR and addressed in Section B.3.4.1 of the Appendix to the Proposed Determination. MEMA commented that the MY2022-2025 standards are not appropriate without changes to the off-cycle credits program. EPA disagrees with this comment and is finalizing its finding that standards remain appropriate with the off-cycle credits provisions currently in place. In response to AISI comments, expanding the program to include credits for potential upstream emissions reductions associated with material production would represent a significant expansion of the credits provisions and EPA believes it is not appropriate or necessary as part of the MTE. EPA's analysis incorporates a modest level of off-cycle credits that are readily available with the current off-cycle provisions including the off-cycle credits menu. The analysis demonstrates that the standards are feasible under the Clean Air Act without an expansion of the off-cycle credits program. Regarding the Alliance comments that EPA dismissed its Draft TAR comments on the off-cycle credits program, EPA notes that although EPA did not propose changes to the program in response to the comments, the comments were addressed in Section B.3.4.1 of the Appendix to the Proposed Determination.

As discussed in Section B.3.5 of the Appendix to the Proposed Determination, the Alliance and Global Automakers also raised issues regarding the off-cycle credits program in its June 2016 petition to EPA and NHTSA.[70] EPA intends to work with the Petitioners and other stakeholders in the future as we carefully consider the requests made in the June 2016 petition. EPA will be taking a separate action to respond to this petition and none of the issues raised in the petition change EPA's assessment of the appropriateness of the MY2022-2025 standards. EPA is making a determination that the MY2022-2025 standards are still appropriate, based on the existing regulations, including the credit provisions raised in the auto petition.

Comments on advanced technology incentives submitted on the Proposed Determination largely overlap with the comments received on the Draft TAR, addressed in the Proposed Determination at Section B.3.4.2 of the Appendix. With regard to Toyota's claim that EPA did not address comments on incentives for full size pickups submitted on the Draft TAR, EPA did consider the comments and the response to the comments is also provided in Proposed Determination Section B.3.4.2 of the Appendix. The analyses supporting EPA's determination show that the standards remain appropriate without changes to the incentives multiplier and large pickup provisions. Further, EPA does not believe that expanding multipliers to additional technologies such as hybrids, as recommended by Ford, is warranted. EPA's analysis is based on cost-effective technologies available to meet the standards with no reliance on the multiplier or large pickup incentives and therefore the agency finds no reason within the scope of the MTE to revisit these provisions. Regarding the comment concerning CAFE credits for EVs and PHEVs, EPA notes that for the GHG program, the current incentives are in place temporarily to promote the initial commercialization of advanced technology vehicles and EPA recognizes that the incentives, to the extent they are used by manufacturers result in a small loss of emissions benefits.[71]

When establishing the standards in the 2012 rule, EPA included incentives for advanced technologies to promote the commercialization of technologies that have the potential to transform the light-duty vehicle sector by achieving zero or near-zero GHG emissions and oil consumption in the longer term, but which face major near-term market barriers. As noted above, providing temporary regulatory incentives for certain advanced technologies will decrease the overall GHG emissions reductions associated with the program in the near term. However, in setting the 2017-2025 standards, EPA believed it was worthwhile to forego modest additional emissions reductions in the near term in order to lay the foundation for the potential for much larger "game-changing" GHG emissions reductions in the longer term. EPA also

[70] "Petition for Direct Final Rule with Regard to Various Aspects of the Corporate Average Fuel Economy Program and the Greenhouse Gas Program," Auto Alliance and Global Automakers, June 20, 2016.
[71] 77 FR 628111-62813, October 15, 2012.

believed that temporary regulatory incentives may help bring some technologies to market more quickly than in the absence of incentives. See 77 FR 62811 et seq.

The Administrator notes that her determination, based on the record before her, is that the MY2022-2025 standards currently in effect are feasible (evaluated against the criteria established in the 2012 rule) and appropriate under Clean Air Act section 202, and do not need to be revised. This conclusion, however, neither precludes nor prejudices the possibility of a future rulemaking to provide additional incentives for very clean technologies or flexibilities that could assist manufacturers with longer term planning without compromising the effectiveness of the current program. EPA is always open to further dialogue with the manufacturers, NHTSA, CARB and other stakeholders to explore and consider the suggestions made to date and any other ideas that could enhance firms' incentives to move forward with and to help promote the market for very advanced technologies, such as battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), and fuel cell vehicles (FCEVs).

Comments on incentives for FFVs and natural gas-fueled vehicles were also addressed in the Proposed Determination at Section B.3.4.3 of the Appendix. EPA continues to believe that the treatment of these vehicles established in the 2012 rule remains appropriate and no changes to the provisions are needed as part of the MTE. The MY2022-2025 standards remain appropriate with the credit provisions currently in place. EPA does not agree that the MTE must include a rulemaking to consider further incentives for these vehicles under the MTE regulations at 40 CFR 86.1818-12(h)(1). EPA also notes that Adsorbed Natural Gas Products (ANGP) provides no data on consumer refueling for their natural gas fueling system to support their claim that the ANGP system would result in at home refueling on the same level as that of PHEVs. ANGP also does not consider possible methane upstream emissions from natural gas production in their comment regarding their views on the equitable credit levels for PHEVs and vehicles equipped with the ANGP natural gas fueling system.

Regarding Mercedes Benz comments that EPA should allow credit to be transferred from heavy-duty 2b/3 class vehicles to light-duty vehicles, EPA believes allowing such credit transfers would raise competitiveness issues since only a small portion of the light-duty vehicle manufacturers produce vehicles in the heavy-duty category and EPA believes it is important to maintain a level playing field for light-duty manufacturers not participating in the heavy-duty market. Also, the heavy-duty 2b/3 standards are based on a different attribute than the standards for light-duty vehicles. EPA is determining the MY2022-2025 standards remain appropriate without allowing credit transfers between heavy-duty and light-duty vehicles. Regarding Mercedes' comment that EPA should consider the potential lack of available credits through credit trading between manufacturers, EPA notes that its analysis does not incorporate credit trading and instead projects that manufacturers are able to comply with the standards without credit trades. Any credit trading that occurs in the future would presumably lower compliance costs.

3.10 Harmonization

<u>Summary of Comments on the Draft TAR addressed in the Proposed Determination</u>

Section B.3.5 of the Appendix to the Proposed Determination considers comments regarding harmonization among EPA, NHTSA, and CARB programs. Separate from the Midterm Evaluation process, on June 20, 2016, the Alliance and Global Automakers submitted a petition asking EPA and NHTSA to make several regulatory changes they believe would better harmonize the programs.[72] The Alliance and Global Automakers raised several of the issues again in their comments on the Draft TAR. Commenters also provided comments regarding the CARB regulatory process and ZEV program. Section B.3.5 of the Appendix provides an overview of the comments and EPA's response. EPA noted that while EPA will be taking a separate action to respond to this petition, none of the issues raised in the petition would change EPA's assessment of the appropriateness of the MY2022-2025 standards. EPA made a proposed determination that the MY2022-2025 standards are still appropriate, based on the existing regulations, including the credit provisions raised in the auto petition. EPA also noted that it intends to work with the Petitioners and other stakeholders in the future as we carefully consider the requests made in the June 2016 petition. We also note that NHTSA has now partially granted the portions of the petition addressed to NHTSA, and intends to conduct rulemaking addressing the issues exclusive to NHTSA raised in the petition.[73]

Summary of Comments on the Proposed Determination

Several commenters raised concerns regarding how the timing of EPA's Proposed Determination may potentially impact the harmonization of EPA's and NHTSA's programs under the National Program. These comments are addressed in Chapter 1 of this RTC document.

Several commenters stressed their view of the importance of program harmonization and reiterated concerns regarding harmonization in the current National Program raised in comments on the Draft TAR. The Alliance and Global Automakers reiterated harmonization issues raised in its petition to the agencies. EPA responded to comments regarding the petition in Section B.3.5 of the Appendix to the Proposed Determination, noting that it will consider the petition in a separate action. Global Automakers commented that this response is insufficient and the issues must be addressed in order to ensure the current program's success through MY2016 which ultimately impacts the bottom line beyond 2016. GM also commented that EPA did not adequately respond to Draft TAR comments regarding harmonization in the Proposed Determination. Toyota commented that one National Program has not been achieved and they expressed disappointment that EPA and NHTSA are not addressing harmonization issues immediately, but that Toyota looks forward to working with the agencies to resolve the matter. The UAW, MEMA, and American Coalition for Ethanol also commented that harmonization is important and that EPA should work with NHTSA and CARB to address program inconsistencies.

Global Automakers commented specifically that EPA did not address their concern that some manufacturers may not fully use GHG air conditioning leakage credits in certain vehicle models due to the manufacturer's product plans and vehicle redesign cycles, thus making the EPA standards more stringent than the NHTSA standards for those manufacturers. Global Automakers suggest EPA adjust the air conditioning credits upward as a way of addressing this issue.

ICCT commented, "EPA has provided ample auto industry flexibilities through technology credits, emission trading, smaller volume company provisions, and footprint indexed standards to

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

[73] 81 FR 95553, December 28, 2016. NHTSA did not grant the petitioners' request that it issue a direct final rule and will instead address changes requested in the Petition in the course of a rulemaking proceeding.

accommodate fleet shifts. These EPA provisions greatly assist automobile industry compliance. Based on the well-designed EPA flexibilities, any further improvement toward a harmonized one national program would best be addressed with adjustments in the Corporate Average Fuel Economy, matching NHTSA's program with EPA's improved manufacturer flexibilities."

Response to Comments on the Proposed Determination

EPA responded to comments regarding program harmonization and the manufacturer's petition in Section B.3.5 of the Appendix to the Proposed Determination, noting that EPA will consider the petition in a separate action. As discussed in EPA's previous response, the agencies have worked to establish a National Program subject to the differences in statutory authorities. The differences in certain aspects of the GHG and CAFE programs existed when the MY2022-2025 standards were first established and do not lead EPA to find that the GHG standards for MYs 2022-2025 are no longer appropriate. EPA is making a final determination that the MY2022-2025 standards remain appropriate based on existing regulations. While EPA will be taking a separate action to respond to the petition, none of the issues raised in the petition would change EPA's assessment of the appropriateness of the MY2022-2025 standards. NHTSA has also indicated that it will consider the auto manufacturers' petition.

EPA does not agree with the Global Automakers comment that the programs are not harmonized due to the situation that some manufacturers may not maximize air conditioning refrigerant leakage credits. EPA does not believe this is an issue for the MTE because manufacturers will have had significant lead time to incorporate air conditioning refrigerant improvements including alternative refrigerants into their vehicles by MYs 2022-2025. Also, as discussed in Chapter 2.2.9 of the Technical Support Document, under EPA's Significant New Alternatives Policy (SNAP) program, manufacturers will be required to use lower-GWP refrigerants beginning in MY2021 for which they will generate full refrigerant credits under EPA's GHG program. For these reasons, EPA expects manufacturers will utilize air conditioning leakage credits and has included their use in its assessment as part of the pathway manufacturers may take to comply with the standards. This issue was also addressed in the 2012 rule where the agencies discussed the possibility of the scenario provided by Global Automakers. The agencies similarly responded there that the comment "reflects a misunderstanding of the agencies' purpose. The agencies have sought to craft harmonized standards such that manufacturers may build a single fleet of vehicles to meet both agencies' requirements. That is the case for these final standards. Manufacturers will have to plan their compliance strategies considering both the NHTSA standards and the EPA standards and assure that they are in compliance with both, but they can still build a single fleet of vehicles to accomplish that goal."[74] EPA also notes that an increase in the credits awarded for air conditioning leakage improvements as suggested by Global Automakers, to the extent that such credits were greater than the actual real-world emission reductions achieved through the air conditioning system improvements, would result in an unwarranted decrease in overall GHG reductions from the program.

[74] 77 FR 63054-63055, October 15, 2012.

Chapter 4: Climate Science and the Further GHG Reductions Beyond 2025

4.1 Climate Science

Summary of Comments on the Draft TAR addressed in the Proposed Determination

EPA received no comments on the Draft TAR discussion of climate science.

Summary of Comments on the Proposed Determination

In the Proposed Determination, Section I.B, EPA presented an overview of climate change science, as laid out in the climate change assessments from the National Academies, the U.S. Global Change Research Program (USGCRP), and the Intergovernmental Panel on Climate Change (IPCC). The Proposed Determination summarized the impacts to human health, to ecosystems, and to physical systems in the United States and around the world, from heat waves to sea level rise to disruptions of food security. Impacts to vulnerable populations such as children, older Americans, persons with disabilities, those with low incomes, indigenous peoples, and persons with preexisting or chronic conditions were also highlighted. The most recent assessments noted by the Proposed Determination have confirmed and further expanded the science that supported the 2009 Endangerment and Cause or Contribute Findings for Greenhouse Gases Under section 202(a) of the Clean Air Act; Final Rule (74 FR 66496), as well as the more recent 2016 Finding That Greenhouse Gas Emissions from Aircraft Cause or Contribute to Air Pollution That May Reasonably Be Anticipated to Endanger Public Health and Welfare (81 FR 54421). As described in the Proposed Determination, the climate system continues to change: in 2015, CO_2 concentrations grew by more than 2 parts per million, reaching an annual average of 401 ppm, sea level continued to rise at 3.3 mm/year since the satellite record started in 1993, Arctic sea ice continues to decline, and glaciers continue to melt. 2015 was the warmest year in the surface temperature record going back to 1880, surpassing the previous record set in 2014, and available data show 2016 will exceed 2015.[75]

EPA received nine comments on the Proposed Determination that touched on climate science issues. Of these comments, eight supported strong standards due to the evidence regarding the impacts of climate change, and considering the large share of national emissions from the vehicle sector. These commenters cite the strong evidence that climate change is real and urgent, the need to protect the nation's children and grandchildren, and the grave threats to public health. The commenters cite the recent USGCRP assessment on the "Impacts of Climate Change on Human Health in the United States" as well as publications by the Asthma and Allergy Foundation, the American Public Health Association, and the American Thoracic Society. The commenters also highlight populations who are particularly vulnerable, including children, older adults, Americans with chronic diseases, low income communities, outdoor workers, and Native American tribal communities. One commenter notes that Millennials will be the primary purchasers of the vehicles addressed by recent vehicle regulations, and that this age cohort will be impacted by climate change and supports cutting greenhouse gases. Another commenter discusses the risks to the economy, and therefore to investors, from unabated climate change.

In contrast, one commenter argues that the estimated reduction resulting from the MY2022-2025 standards in 2025 would be 0.6 percent of national emissions, projected temperature

[75] NOAA (2016): http://www.noaa.gov/news/november-2016-ranks-as-5th-warmest-on-record-for-globe

reductions in the year 2100 would be less than two hundredths of a degree Celsius, and this magnitude of benefits is "trivial" and "paltry" and does not justify the potential costs of the regulation.

Response to Comments on the Proposed Determination

EPA has carefully considered all the comments regarding the science. The major assessments demonstrate the continued and, for certain outcomes, increased certainty and likelihood that GHGs impact health and welfare now and in the future. It continues to be EPA's view that the scientific assessments of the IPCC, USGCRP, and the National Research Council (NRC) represent the best reference materials for determining the general state of knowledge on the scientific and technical issues before the agency in making an endangerment decision. No other source of information provides such a comprehensive and in-depth analysis across such a large body of scientific studies, adheres to such a high and exacting standard of peer review, and synthesizes the resulting consensus view of a large body of scientific experts across the world. These assessments draw synthesis conclusions across thousands of individual peer-reviewed studies that appear in scientific journals, and the reports themselves undergo additional peer review. Thus, the assessments reflect extremely high quality, rigorous work that has gone through an exacting standard of peer review. This provides assurance that the Administrator is basing her judgment on the best available, well-vetted science that reflects the consensus of the climate science research community. For these reasons, EPA places primary and significant weight on these assessment reports in reviewing the state of climate science.

These assessments support those claims of commenters who stated that the climate change problem is real and urgent, with implications for public health and many vulnerable populations.

With regards to the commenter who claimed that the benefits of the rule are "trivial" and "paltry," EPA finds that these claims are without merit. First, the commenter highlighted the emissions reductions in 2025 due to the impacts of the rule on MY2022-2025 vehicles. Due to the rate of vehicle turnover, only a relatively small fraction of the vehicles on the road in 2025 would be MY2022 or later. As the commenter noted, "EPA admittedly projects larger emissions savings decades into the new standards."

Second, with regard to the temperature impacts, EPA previously responded to similar comments in 77 FR at 62898 (from the 2012 final rule preamble). We repeat that response here:

> IER and a number of private citizens asserted that the reductions in temperature and other climate factors are too small to be meaningful. However, as has been stated, no one rule will prevent climate change by itself. As stated in the Endangerment and Cause or Contribute Findings for Greenhouse Gases Under section 202(a) of the Clean Air Act; final rule (74 FR at 66543), "The commenters' approach, if used globally, would effectively lead to a tragedy of the commons, whereby no country or source category would be accountable for contributing to the global problem of climate change, and nobody would take action as the problem persists and worsens." While this rule does not singlehandedly eliminate climate change, it is an important contribution to reducing the rate of change, and this reduction in rate is global and long-lived. EPA appropriately placed the benefits of reductions in context in the rule, by calculating the likely reductions in temperature and comparing them to total projected changes in temperature over the same time

period. In addition, EPA used the social cost of carbon methodology in order to estimate a monetization of the benefits of these reductions (see section III.H.6), and the net present value resulting from the CO_2 reductions due to this rule (between years 2017 and 2050) was calculated to be between tens to hundreds of billions of dollars. As noted above, the D.C. Circuit pointedly rejected the argument that EPA should refrain from issuing GHG standards under section 202(a) due to claimed lack of mitigating effect on the endangerment, and further held that "the emission standards would result in meaningful mitigation of greenhouse gas emissions" in the form of "960 million metric tons of CO_2e over the lifetime of the model year 2012–2016 vehicles." *Coalition for Responsible Regulation v. EPA*, 684 F. 3d 102, 128 (D.C. Cir. 2012); projected emissions reductions of this MYs 2017– 2025 rule are projected to be approximately double those of the MYs 2012–2016 rule and thus, in the D.C. Circuit's language, "result in meaningful mitigation of greenhouse gas emissions."

4.2 Post-2025 Standards

Summary of Comments on the Draft TAR addressed in the Proposed Determination

While the agencies did not address post-2025 issues in the Draft TAR, the agencies did receive comments on the need to consider long-term climate issues from a number of organizations, including Consumers Union, The International Council on Clean Transportation, University of Illinois Applied Environmental Law Program et al, Northeast States for Coordinated Air Use Management, National Association of Clean Air Agencies, California Air Resources Board, American Lung Association et al., and Fuel Freedom Foundation, among others. In part as a response to these comments, EPA included in the Proposed Determination a broader discussion of the need and opportunity for additional GHG reductions post-2025, as described next.

Summary of Comments on the Proposed Determination

In Section V of the Proposed Determination, EPA discussed the need and opportunity for substantial GHG emissions reductions from light-duty vehicles beyond 2025, as a step toward having a dialogue with stakeholders. For illustrative purposes, Figure V.1 in that document presented a figure that showed projections for total U.S. light-duty vehicle plus upstream fuel GHG emissions out to 2050 under three scenarios: 1) a business-as-usual scenario with no regulatory changes after 2025, 2) a scenario where standards are reduced by 4.5 percent per year for MY2026-2050, and 3) a scenario fitted to achieve the upper bound of the global GHG emissions reduction range projected by the Intergovernmental Panel on Climate Change to limit the global temperature rise to below 2°C. The section also briefly discussed the potential for long-term transformational changes in the light-duty vehicle sector, and the possible impacts on GHG emissions.

Five organizations specifically commented on the post-2025 discussion in the Proposed Determination: ICCT, Environmental Defense Fund (EDF), Center for Biological Diversity (CBD), American Council for an Energy-Efficient Economy (ACEEE), and the New York State Department of Environmental Conservation (NYSDEC).

All five commenters expressed support and/or appreciation for beginning the dialogue about post-2025 issues. Two commenters provided more detailed comments on potential longer-term goals. ICCT specifically encouraged the federal agencies to assess prospects for 2026-2030 standards that reflected annual reductions in GHG emissions and fuel consumption of 5 percent per year. It further stated that 2030 is an appropriate time frame given that it would give the industry similar lead time to what it initially had for the 2025 standards, and since California is likely to begin work on 2030 climate policies in the near future. The Center for Biological Diversity objected to the 2°C global temperature rise basis for one of the curves presented in the Proposed Determination, and advocated for an alternative target based on the "well below 2°C" language that was included in the Paris climate agreement.

Two of the commenters, ICCT and the Environmental Defense Fund, also observed that there is additional technology available to automakers beyond that necessary to meet the 2025 standards, and more likely to be developed in the future due to ongoing innovation.

Response to Comments on the Proposed Determination

EPA appreciates the comments on this topic, as they reflect the very dialogue that Section V was intended to spark. On the regulatory time frame of 2030 suggested by ICCT, EPA notes that there are advantages and disadvantages with shorter and longer time frames—the former provides more technological certainty but less time for innovation, while the latter entails less technological certainty but more time for innovation. With respect to the long-term global temperature rise goal raised by the Center for Biological Diversity, EPA notes that the curves presented in the Proposed Determination were selected for illustrative purposes only and do not reflect any judgment by EPA as to their sufficiency from a climate perspective or feasibility from a technology perspective. EPA further notes that the upper bound of the range of global GHG emissions reduction that would likely limit global temperature rise to 2°C, used in the illustrative curve in the Proposed Determination, is directionally consistent with going "below 2°C," though unlikely to limit the global temperature rise to 1.5°C.

Finally, EPA reiterates that its goal in including the discussion of post-2025 issues in the Proposed Determination was simply to continue a dialogue, and we are pleased that this in fact is occurring.